THE Petroleum Engineer

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Meetings

American Gas Association, International Gas Conference and 15th Annual Meeting—Stevens Hotel, Chicago, September 25 to 30.

National Safety Council, 22nd Annual Congress—Stevens Hotel, Chicago, October 2 to 6.

A. I. M. E. Petroleum Division, Western Section—Los Angeles, September 29. Mid-Continent Section—Baker Hotel, Dallas, October 6 and 7.

American Petroleum Institute, Annual Meeting—Stevens Hotel, Chicago, October 24 to 26.

American Society of Chemical Engineers—Roanoke, Va., December 6, 7 and 8.

District Chapter Meetings, Department of Production, A. P. I.:—
San Joaquin Valley, Oct. 17.
Panhandle, Texas, Oct. 10.
Burbank, Okla., Oct. 11.
Oklahoma City, Okla., Oct. 12.
Wichita, Kansas, Oct. 14.
Seminole, Okla., Oct. 17.
Drumright, Okla., Oct. 16.
East Texas, Oct. 27.
Wichita Falls, Tex., Oct. 30.

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MEMBER A. B. C.

NRA MEMBER U.S. WE DO OUR PART

MEMBER A. B. P.

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The Course of Oil

By K. C. SCLATER

Bringing Order Out of Chaos

Confidence that the NRA code will be an efficient means to control supply and demand was seen in the upward trend of crude and gasoline prices a few days before the code went into effect. The full significance of what this means is not yet apparent. Thus far, the Administration has not seen fit to invoke the price-fixing provisions of the code; before resorting to artificial measures it prefers to delay action until the economic laws of supply and demand have been given an opportunity to exert their influence. Ground for complaint by proponents of price-fixing has been removed by the substantial advance in crude prices and it appears at present that a compromise has thus been brought about. In the matter of price, however, the industry must watch its step; the NRA has the price-ratio of crude to gasoline under close observation and should the ratio appear to be out of line immediate action will be forthcoming to correct it. On this point the NRA has been explicit.

It was evident during the hearings on the code that many oil men had lost faith in the economic laws of supply and demand. This is not surprising. The fact is: there has never been any agency through which the industry could make a concerted effort to hold supply to demand without running afoul of state or federal laws. A national emergency has removed this barrier, and therein lies the potency of the NRA code as a guide by which to bring order out of chaos and permit the petroleum industry of the United States to conduct its operations on a sound basis. With so much available oil in sight the holding of supply and demand in balance is essential to the establishment of fair prices.

Angles to the price problem and how it affects different units in the industry are many. Two-thirds of the domestic crude produced is refined by the companies that produce it; the remaining one-third is produced by companies having no refining facilities and by producer-refiners who produce in excess of their refinery requirements. The producer who does not refine his product is affected by crude prices principally; the producer-refiner is affected by the prices of both crude and refined products, the degree to which he is affected being dependent on the proportion of his crude production he refines; and the refiner who does not produce oil is affected by the prices of crude and refined products, chief among the latter being gasoline. This division of interest in the price structure has given rise to a complex problem. It is a factor that has been an obstacle to unity of action. They cannot all see eye to eye.

One of the objects of the code is to abolish unfair competition and bring about a condition in the industry whereby products shall not be sold below the cost of production. This implies that the adoption of advanced practices and efficiency will be rewarded; for when prices are low inferior uses for products increase and efficiency in producing and manufacturing operations tend to become unprofitable. High prices on the other hand are conducive to efficiency; the wide-awake producer is impelled to adopt efficient practices, and the refiner improved methods and processes in order that he may obtain the maximum yield in his refining operations.

That the supply will be controlled to meet the legitimate demand is virtually assured by the code. Further, it is assured that it will continue to be controlled. Never has the petroleum industry had this assurance before. Far-sighted producers and refiners already recognize the possibilities in the present situation. Many are making plans to install equipment and improved processes to meet the demand for a higher grade product. One of the vital features of the NRA code is the almost dead certainty that it will be enforced to the letter.

Experience has shown that when supply and demand are in balance the price will adjust itself to meet the highest, and not the lowest, production cost of the commodity meeting the demand. Upon this experience is based the assurance that efficient operation under the NRA code will be rewarded. The benefits that accrue to an operator under the code will be in proportion to the effort he puts forth to improve his method of operating.

Estimates of demand being made by a disinterested federal agency will remove the possibility of manipulation of prices or production control by any group within the industry. There is every assurance that the strict compliance demanded of all units in the industry with the code provisions will be achieved. So long as the code is in effect legitimate operators are not likely to be harassed by violent fluctuations in prices; these will probably follow along a more even course than in the past. When this condition is brought about and the means by which it was attained is realized and understood by the rank and file of the industry, a return to the old order of things will become a most remote possibility.

Considering the haggling that preceded the adoption of the code and the dire predictions that have been made regarding federal control, the NRA code has been accepted by the entire petroleum industry with remarkably good grace. The action taken by the Texas Railroad Commission in issuing an emergency order requiring the daily production of all except marginal wells in the State to be curtailed twenty-five per cent in order that the code could be put into immediate effect on September 8, was gratifying evidence of the unanimity of purpose that has developed among all groups connected with the industry.

« « « HIGHLIGHTS IN OILDOM » » »

Oil Output Reduced Under Code

Effective September 8, the daily production of crude oil within the United States was fixed at 2,409,700 bbl., in formally putting into effect the NRA trade code. This figure compares with an average output of more than 2,750,000 bbl. daily during the preceding weeks.

Texas, which has been producing 1,216,250 bbl. daily, received the greatest reduced allocation when its production was limited to 975,200 barrels. The division of the production among the other oil states was announced by Administrator Ickes as follows: Oklahoma, 540,000; California, 480,000; Kansas, 112,000; Arkansas, 29,000; Louisiana, 70,000; New Mexico, 41,400; Rocky Mountain States, 38,900; Appalachian district, 94,200, and Michigan, 30,000 barrels.

●

Texas Oil Output Cut 25 Per Cent

Indication that the State of Texas will coöperate fully with the plans of the Federal Government in administrating the petroleum code has been shown by the issuance of an emergency order by the Railroad Commission, which requires producers to cut their production exactly 25 per cent, except on marginal wells. This order became effective September 8, and will remain in force until sometime after September 16, when the Commission will hold an all-State proration hearing. After the hearing the Commission may adopt another method for cutting the required 240,800 bbl. from the State's daily crude oil output. Curtailment of crude production in Texas is the most difficult task in the allocation of oil recovery by states confronting code administrators, and the promptness with which the Railroad Commission has acted is very encouraging to the entire industry.

●

Rapid Increase in Crude Prices

Higher crude prices were established in the Mid-Continent and Gulf Coast fields, effective September 9, when most of the major purchasing companies posted increases of from 10 to 15 cents per barrel. This was the third increase in crude prices within the last month. The new postings give East Texas a price of 90 cents, while in Oklahoma, Kansas and North Texas the price range is from 73 to 97 cents. These price raises have been made without any coercive action from the Federal Government. The board of directors for the industry has agreed that a minimum price of $1.00 shall be paid for crude oil, and it is believed that this price will become a reality as soon as the various states are able to bring their output down to the figures allotted them by the federal board of directors.

Pennsylvania grade crude oil continued its upward swing last month when another 10-cent per bbl. increase was posted by purchasers. This is the eighth raise since May 9, whereby a total of $1.05 a bbl. has been added to the value of crude oil in the region. Bradford grade oil is now bringing $2.35 a barrel.

California operators were cheered by the posting of the first $1.00 per bbl. price schedule in more than a year, when a 15-cent increase was given Signal Hill field crude.

●

Texas Pipe Line Rates Lowered

The Texas Railroad Commission, in a hearing on September 5, promulgated a tariff on oil pipe line charges under the new State law and ordered reductions effective December 1 estimated at between 16 and 20 per cent. A reduction of 33 1/3 per cent was ordered as dunnage deductions. The present two per cent tank strapping deduction was cut to one per cent. The commission estimates that the saving through these reductions will aggregate $29,623,400 annually for producers.

●

Texas May Restrict New Drilling

Rigid restriction of new drilling operations in Texas may result from an order issued by the Texas Railroad Commission, which states that no permit to drill an oil well shall be allowed until notice of hearing has been given and the hearing held by the commission. At this time Texas is the site of one-third of the drilling wells in the entire United States, and during the past month approximately one-half of the new locations for the Nation were made in this State. Curtailment of drilling activity in this state would be a tremendously beneficial aid to stabilization efforts.

●

Oil Industry Under NRA Code

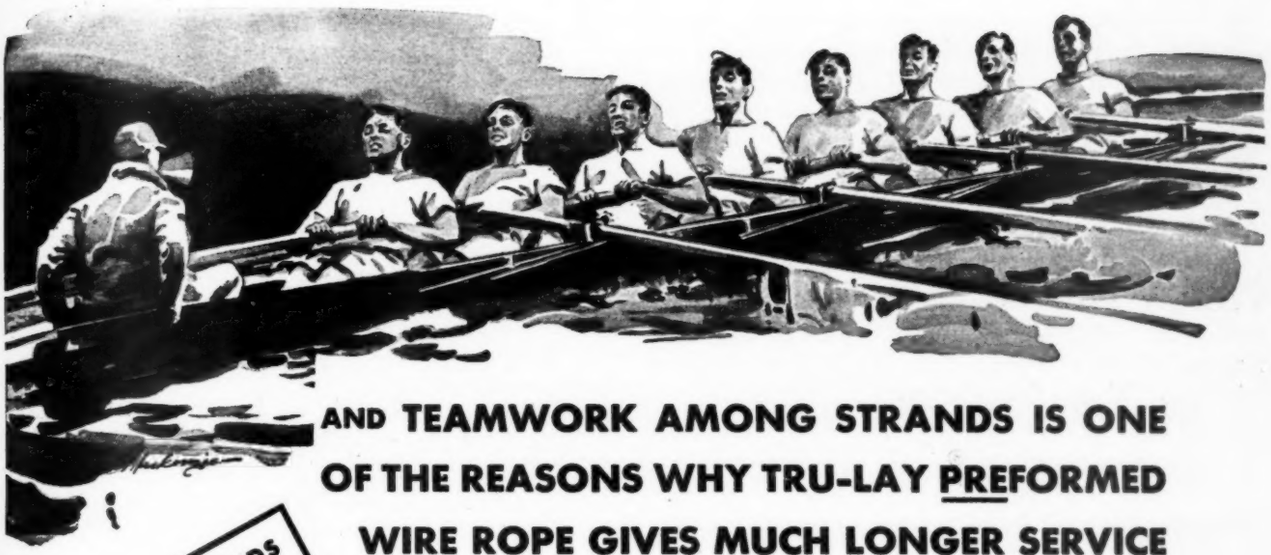
The oil industry's code, which was approved by President Roosevelt on August 19, became effective on September 2. The necessity of setting up machinery to direct the activities of the industry under the provisions of the code and formulation of plans by the various companies to carry out recommendations has caused delay in putting it into actual effect; however, substantial progress has been made and, despite the many and varied problems to work out in conforming operations to the provisions of the code, many companies are already complying fully with its regulations.

●

Proration Violation A Felony

A new bill making violations of the Railroad Commission's proration orders a felony punishable by fine and imprisonment went into effect in Texas on September 1. This materially tightens proration enforcement, giving the commission further powers to hold production under control. A group of refiners have instituted a suit to test the new law, but it has not yet come up for trial. This new law is very timely, as under the NRA pertoleum code it is necessary for production in the State to be restricted another 240,800 bbl. daily, and the commission has heretofore experienced much trouble in curtailing crude recovery.

PERFECT CO-ORDINATION



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LATEST ACTIVITIES IN THE OIL FIELDS

THE finding of a large gas producing well six miles east of the Sarnosa field, southernmost of the Government Wells group of pools in Duval County, South Texas, opens the way for another Government Wells trend. This is the first important strike east of the present group of fields, although production has been found to the west. While only a gas well, it leads to possible oil production on the flanks of the structure. Further work in the regular Government Wells trend continues to result in minor extensions and new production.

●

Indications are that a new South Texas field is being opened in Hidalgo County, which heretofore has remained unproductive. A test in the western portion of the county is showing plenty of oil and gas from a sand at 3179-87 ft., and casing is being set without a drill stem test.

●

The effects of numerous deals, involving more than $1,000,000 in cash, in the Greta field, Refugio County, South Texas, are indicated by increased drilling activity. New operations, locations and completed wells now total 83, with prospects that this number will be enlarged soon.

●

The most interesting feature of wildcatting in the Texas Gulf Coast is the Yount-Lee Oil Company's No. 1 Boyt, which was last reported drilling below 9825 feet. This is the deepest test ever drilled in Texas and is not far from the world's record depth of slightly less than 11,000 feet. The well is located in Liberty County.

The new producing area southeast of Livingston in Polk County, Texas Coastal district, was further defined during the month when a southeast output test proved unproductive.

●

Magnolia Petroleum Company has opened a new Wilcox sand producing area in Oklahoma. This company's wildcat test more than a mile from production in the West Chandler pool of Lincoln County, came in for an initial flow of 30 bbl. per hour and when deepened to 4988 ft., made 1330 bbl. in 24 hours. This is the second important new field in as many months for the Sooner state, which has been unusually quiet for more than a year.

●

The first new well in the northeastern section of Kansas for some time, is an extension producer in Bourbon County, near the Anderson, Linn and Allen county lines. The well, owned by the Bourbon Oil Company, is good for 60 bbl. daily from a depth of 635 feet. The Bourbon Company control surrounding acreage and have set a 60-hp. direct-driven compressor with which it expects to maintain a semi-flush condition in the field by pumping air and gas into the sand to maintain the original rock pressure.

●

Major increases in production from the Central Michigan fields since July 1, due largely to new completions, has resulted in the exercise of proration by the major pipe line companies. Michigan production has jumped from 15,000 bbl. daily on July 1 to 30,000 bbl. on September 1. The new Porter field is producing about 20,000 bbl. every 24 hours.

AVERAGE CRUDE OIL PRICES

California		Arkansas	$ .60
Playa Del Rey	$ .90	Louisiana	
Coalinga	.81	North Louisiana	.84
Long Beach	1.00	Gulf Coast	.91
Montana	1.10	Illinois	1.12
Wyoming	1.25	Kentucky	1.07
Colorado	.89	Indiana	1.05
New Mexico	.65	Ohio	
Texas		Lima	1.20
North Central	.89	Wooster	1.05
Panhandle	.73	Michigan	.90
West Texas	.60	Pennsylvania	
Gulf Coast	.91	Bradford	2.35
Darst Creek	.77	Southwest	2.02
East Texas	.90	West Virginia	1.97
Kansas	.89	Canada	1.85
Oklahoma	.89		

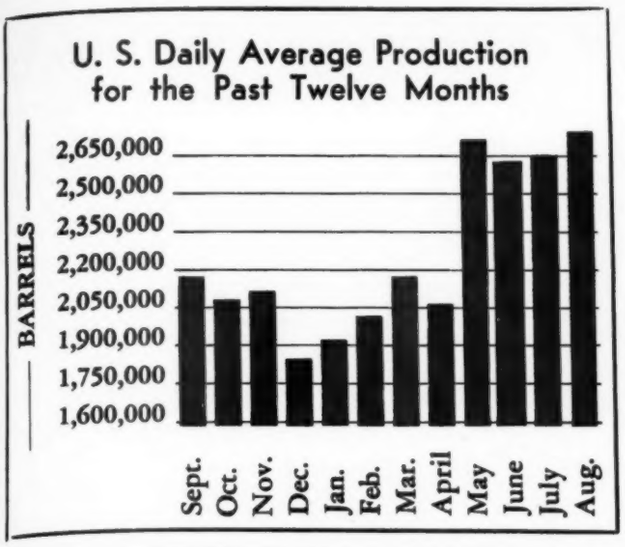
DAILY AVERAGE CRUDE OIL PRODUCTION

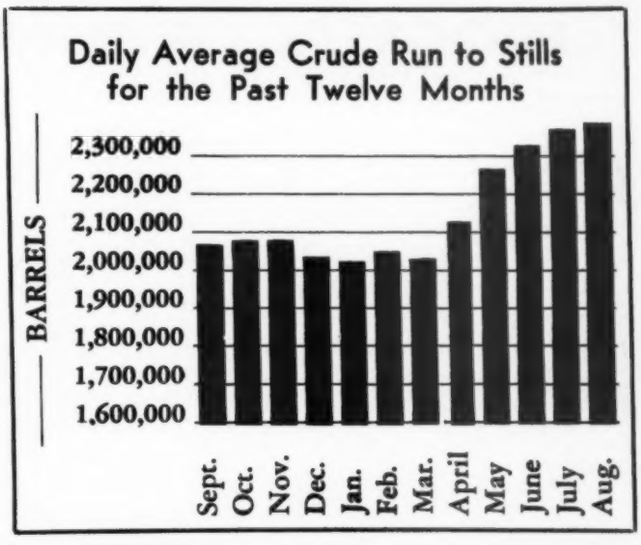
(Figures in Barrels)

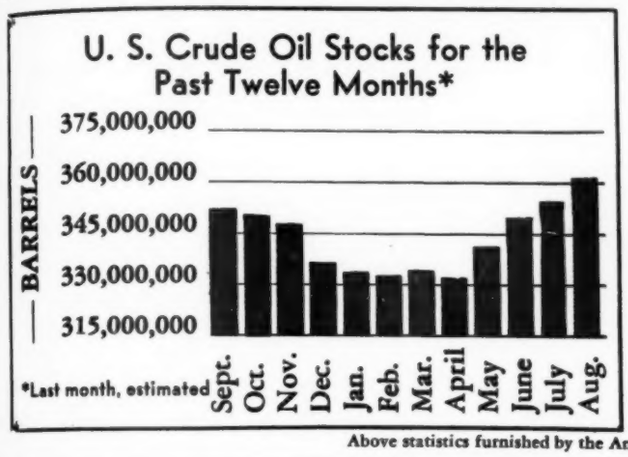
Furnished by A.P.I.

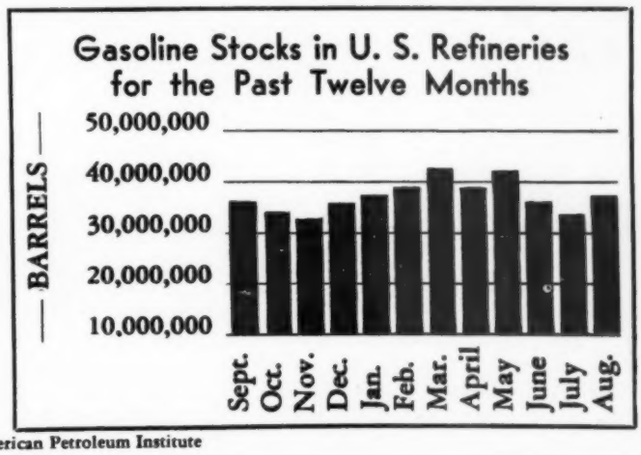
	Week Ended Aug. 26, 1933	Week Ended July 29, 1933	Week Ended Aug. 27, 1932
Oklahoma	605,500	600,600	387,150
Kansas	128,950	125,500	95,250
Panhandle Texas	47,600	55,600	53,650
North Texas	53,050	50,750	49,800
West Central Texas	21,900	21,850	24,700
West Texas	161,200	158,200	172,750
East Central Texas	58,550	58,400	56,800
East Texas	605,950	583,650	327,700
Conroe	86,800	84,100	6,750
Southwest Texas	51,950	52,600	53,850
North Louisiana	26,150	26,050	29,300
Arkansas	31,300	31,250	34,100
Coastal Texas (Not including Conroe)	129,250	125,750	116,750
Coastal Louisiana	46,850	46,450	32,300
Eastern (Not including Mich.)	92,500	93,100	101,000
Michigan	28,400	19,950	22,650
Wyoming	28,850	29,700	33,350
Montana	6,450	7,250	7,450
Colorado	2,400	2,400	2,750
New Mexico	41,400	37,600	31,550
California	501,400	487,100	474,400
TOTAL	2,756,400	2,697,850	2,114,000
Texas	1,216,250	1,190,900	862,750

[1]Production figures furnished by the American Petroleum Institute.









Above statistics furnished by the American Petroleum Institute

Summarized Operations in Active Fields for August, 1933

Fields	Completions	Producers	Locations	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS									
East Texas	164	163	242	61	120	3600	2	40	Rotary
Duval County	18	14	51	7	21	2300	2	22	Rotary
Conroe	34	34	36	6	40	5200	2	38	Rotary
OKLAHOMA									
Oklahoma City	4	3	3	20	18	6500	3	39	Rotary
KANSAS									
McPherson County	10	8	18	10	29	2900–4300	2	38	Rot.-Cab.
Ellsworth Arch	8	5	16	9	29	3300	4	37	Cable
Harvey County	7	7	19	9	21	3450	2 or 4	37	Rot.-Cab.
CALIFORNIA									
Kettleman Hills	0	0	4	1	12	8300	3 or 4	40	Rotary
Long Beach	3	3	6	6	27	7000	3	26	Rotary

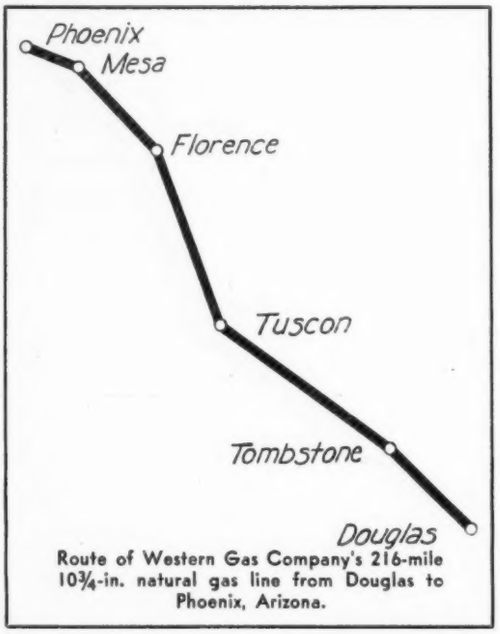
Field Activities by States for August, 1933

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1932 (In Barrels)
	August	July	August	July	August	July	August	July	August	July	
Arkansas	7	7	0	0	2	3	7	11	32	32	11,907,000
California	20	23	17	22	179	282	39	35	130	131	178,128,000
Colorado	4	3	1	0	....	....	4	5	58	55	1,177,000
Illinois	1	2	1	0	....	....	1	1	13	12	4,661,000
Indiana	14	2	11	3	....	....	4	2	25	53	804,000
Kansas	33	44	27	32	80	84	30	21	101	151	34,300,000
Kentucky	15	15	7	8	....	....	3	3	51	50	6,264,000
Louisiana	45	45	19	21	106	117	39	35	140	145	21,478,000
Michigan	26	20	19	12	76	45	65	45	83	84	6,729,000
Mississippi	5	4	4	2	....	....	3	4	15	14	Gas Prod.
Montana	10	2	3	2	....	....	7	3	48	36	2,449,000
New Mexico	5	0	2	0	....	....	10	8	45	51	12,511,000
New York	0	0	0	0	....	....	4	5	21	17	3,501,000
Ohio	55	48	34	41	....	....	33	25	129	119	4,597,000
Oklahoma	96	69	60	41	104	107	98	83	253	285	152,621,000
Pennsylvania	16	8	12	3	....	....	13	8	87	68	12,403,000
Texas	475	358	334	249	1174	744	149	116	701	620	311,069,000
West Virginia	26	16	22	13	....	....	23	25	52	54	4,472,000
Wyoming	5	2	4	1	....	....	11	10	70	63	12,359,000
TOTAL	854	668	558	450	1730	1382	543	445	2053	2040	781,845,000

PROGRESS OF MAJOR PIPE LINE WORK

By WARREN L. BAKER

CONSTRUCTION work was recently commenced by the Western Gas Company, El Paso, Texas, on its 216-mile 10¾-in. gas transmission system from Douglas to Phoenix, Arizona, via Tombstone, Tucson, Florence and Mesa. Much of the work in laying this line will be done by hand labor and it is not expected that it will be completed until January 1, 1934. Bechtel-Kaiser Company, Ltd., and Henry J. Kaiser Company have been awarded the contract for construction of the line. Offices have been opened at Tucson and Phoenix. The estimated cost of the line is $2,000,000, which has been advanced by the Reconstruction Finance Corporation. The A. O. Smith Corporation of Milwaukee, Wis., and the Republic Steel Co., Youngstown, Ohio, received orders for the pipe.



Route of Western Gas Company's 216-mile 10¾-in. natural gas line from Douglas to Phoenix, Arizona.

●

One of the features of the six-year industrial recovery plan for Mexico, which will become effective soon, is the proposed construction of a natural gas pipe line from the gas fields of Zapata and Starr counties, South Texas, to Mexico City and intermediate towns. The new pipe line will parallel the existing one that runs from these fields to Monterrey. Its route from Monterrey to Mexico City will be via Saltillo, San Luis Potosí, Querétaro and a number of smaller towns. The United Gas Company (owner of the line to Monterrey) and the Electric Bond and Share Company will be parties to financing the project, with the Mexican Government assuming part of the cost, according to present plans.

●

Northern Natural Gas Company, Omaha, Neb., has let a contract to Fredell Construction Company of Amarillo, Texas, for the construction of a 60-mile 18-in. extension of its gas transmission system from Owatonna, Minn., to Minneapolis and St. Paul. The new line will increase the company's load 20,000,000 cu. ft. daily. The company has placed an order for 6000 tons of pipe with the Youngstown Sheet and Tube Company. This company is also laying a 14-mile natural gas line from the gas fields in Rush County, Kansas, to connect with its 26-in. trunk carrier from Texas to Minnesota.

●

Sarnia Oil and Gas Company of Sarnia, Ontario, Canada, proposes a 120-mile natural gas line from producing areas in Sarnia and Enniskillen townships in Lambton County to Stratford by way of St. Marys. It is also possible that a lateral line will extend the service to Mitchell, Seaforth, Clinton and Goderich. The project represents an expenditure of approximately $1,500,000 for the line to Stratford and nearly $2,000,000 if extended to Goderich. Leo A. Wilson, president of the company, states that the project will be undertaken this fall, provided franchises can be obtained and contracts prepared within the next few weeks.

●

Michigan Natural Gas Corporation, Mt. Pleasant, Mich., it is understood, will proceed with plans for constructing a 157-mile natural gas line from Central Michigan fields to Saginaw, Bay City, Flint and Pontiac, as reported in the July issue. Cost of the development is estimated at more than $3,000,000. The system will include several gasoline plants.

●

Gas Fuel Service Company has received permission from the Railroad Commission to supply natural gas to communities in Kings and Fresno counties of California. Plans call for several hundred miles of gas lines into the two counties, the route of the line taking it north from Kettleman Hills along the west side of Fresno County to Mendota and Firebaugh. C. C. Friend is president of the company.

●

The cities of Ackerman and Houston, Mississippi, have granted the Independent Utilities Company franchises to lay lines for the distribution of natural gas within the corporate limits. The gas is to be furnished from a proposed pipe line from Jackson, Miss., gas field to Muscle Shoals, Ala., which will touch practically every town of any size in this section of the state.

●

Clanton, Ala., recently granted a franchise for natural gas distribution to the Tri-County Utilities Company, a 35-mile line from the Southern Natural Gas Company's (Birmingham, Ala.) main line. The Clanton line will take off from the main line between Robinson Springs and Coosada and will serve a number of intermediate communities.

●

Consumers Power Company has started construction of a 30-mile gas main from Midland to Saginaw, Michigan, to connect with the main line built from the Broomfield gas pool in Isabella County to Midland two years ago. The Midland-Saginaw connection will be of 10-in. welded construction.

●

Panhandle Eastern Pipe Line Company, Kansas City, Mo., has purchased the Macon Gas and Electric Co., Macon, Mo., and plans to construct a 25-mile natural gas transmission line from Moberly to Macon.

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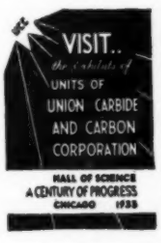

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LINDE OXYGEN · PREST-O-LITE ACETYLENE · OXWELD APPARATUS AND SUPPLIES · UNION CARBIDE

THE MONTH'S ACTIVITIES IN REFINING

By F. R. STALEY

Per Cent Refining Capacity Operated

Eastern Division 79.5 Per Cent **Central Division 74.4 Per Cent** **Western Division 55.1 Per Cent**

IT is likely that under the so-called price fixing sections of the NRA code that became effective September 2, work of modernizing petroleum refineries will be stimulated so that advantage may be taken of additional profits to be gained by more efficient operation and recovery. The formula for establishing the price of crude oil puts a premium on cracking operations, in that a greater recovery is possible. It will be to the advantage of the refiner, particularly as crude and gasoline prices rise, to increase his yield of gasoline at the expense of by-products and thus curtail his consumption of raw crude.

●

Of particular interest to refiners is the installation of the first pulverized petroleum coke boiler unit in an industrial plant. The disposal of coke accumulations at crude oil refineries has long been a problem of importance, therefore, this installation may be the forerunner of a development of much significance. The Henry Vogt Company has received a contract for installing a 406-hp., 200-lb. working pressure unit at the Dallas (Texas) Cotton Mills. The boiler will use coke from a Holmes Manley unit at The Texas Company's Gates refinery in West Dallas. The boiler will operate in conjunction with a ball-type pulverizer.

●

The Ethyl-Dow Chemical Company, subsidiary of Dow Chemical Company, Midland, Mich., and Ethyl Gasoline Corporation of New York City, is erecting a commercial bromine plant for the production of bromides from sea water, near Wilmington, N.C. The plant will be ready for operation within five months, it is stated, and its output will be used exclusively for the production of Ethyl fluid for gasoline. This development is the result of researches started in 1925, to find a source, and method of isolation, of bromine for this purpose. Bromine is essential to the manufacture of Ethyl fluid as now supplied to the refining trade for making high anti-knock premium gasolines. The plant is being built in units, each capable of producing a quarter of a million pounds, or 125 tons, of bromine per month. To produce this amount requires the processing of 13,000 gallons of sea water per minute for 24 hours per day.

●

The United Gas Corporation, Houston, Texas, has let a contract for the construction of a 30,000-gallon stabilizing unit at its Myrtis, La., plant. Work is already under way. Petroleum Engineering, Inc., associated with the Arthur G. McKee Company, designed and is engineering and equipping the plant.

●

Lobitos Oilfields, Ltd., will erect a refinery in the United Kingdom. A site has been acquired at Ellesmere Port, on the Manchester Ship Canal, which will permit enlargement of the refinery in due time if the results appear to warrant such a course. The board of the company states that this construction work will assure the company of an outlet for part of the crude oil produced by its Peruvian subsidiary and, as the receipts for the products will be in sterling exchange, difficulties will be eliminated so far as that portion of the crude oil production is concerned.

●

The Chalmette Petroleum Corporation is installing a combination vapor recovery and stabilizing unit to take care of gases from its skimming and cracking operations at its Chalmette, La., refinery. The unit, which is the vapor rectifying type of vapor recovery plant, is being installed by Petroleum Engineering, Inc.

●

Louisiana Oil Refining Corporation, Shreveport, La., plans the installation of new gasoline recovery and stabilization systems. It is understood that the company will completely modernize its cracking process when these and other improvements now planned are completed.

●

Crown Oil & Refining Company, Houston, Texas, plans the erection of a new gasoline recovery unit of the absorption type.

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks, Week Ending August 26, 1933

A.P.I. Figures

(Figures in Barrels of 42 Gallons Each)

DISTRICT	Per Cent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Per Cent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbl.	Gas and Fuel Oil Stocks Thousands of Bbl.
East Coast	100.0	516,000	88.7	15,031	9,077
Appalachian	92.6	92,000	65.9	2,066	881
Ind., Ill., Ky.	97.3	356,000	83.8	6,952	5,091
Okla., Kans., Mo.	82.1	267,000	70.4	5,009	3,985
Inland Texas	58.7	82,000	50.9	1,301	1,821
Texas Gulf	98.0	473,000	95.1	5,503	7,269
Louisiana Gulf	100.0	131,000	80.9	1,421	1.944
N. Louisiana-Ark.	92.6	57,000	74.5	253	619
Rocky Mountain	78.8	34,000	53.5	885	757
California	96.9	465,000	56.6	14,189	100,033
Total Aug. 26, 1933..	92.2	2,473,000	74.7	52,610	131,477
Total Aug. 19, 1933..	92.2	2,488,000	75.2	51,438	130,678

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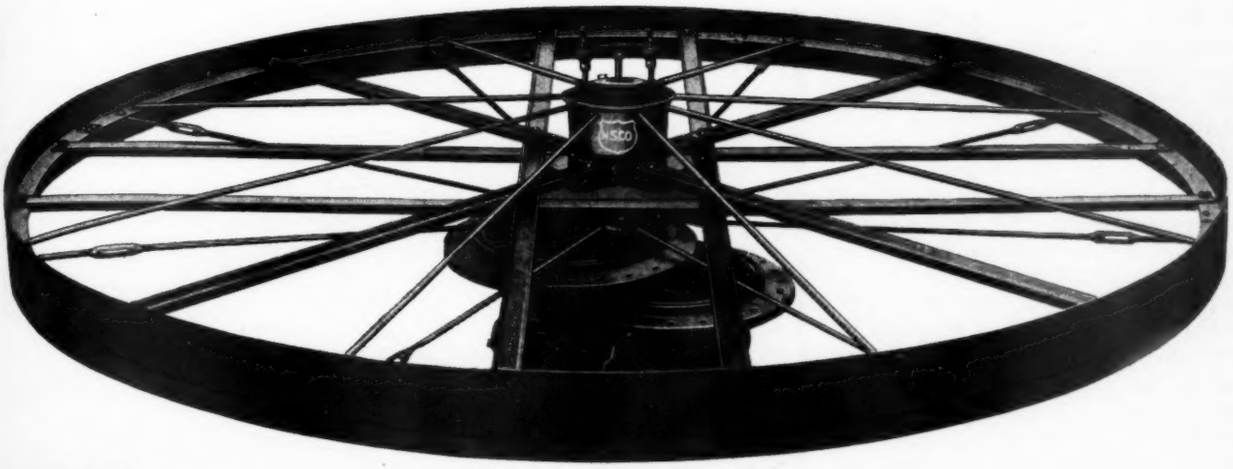

12 C

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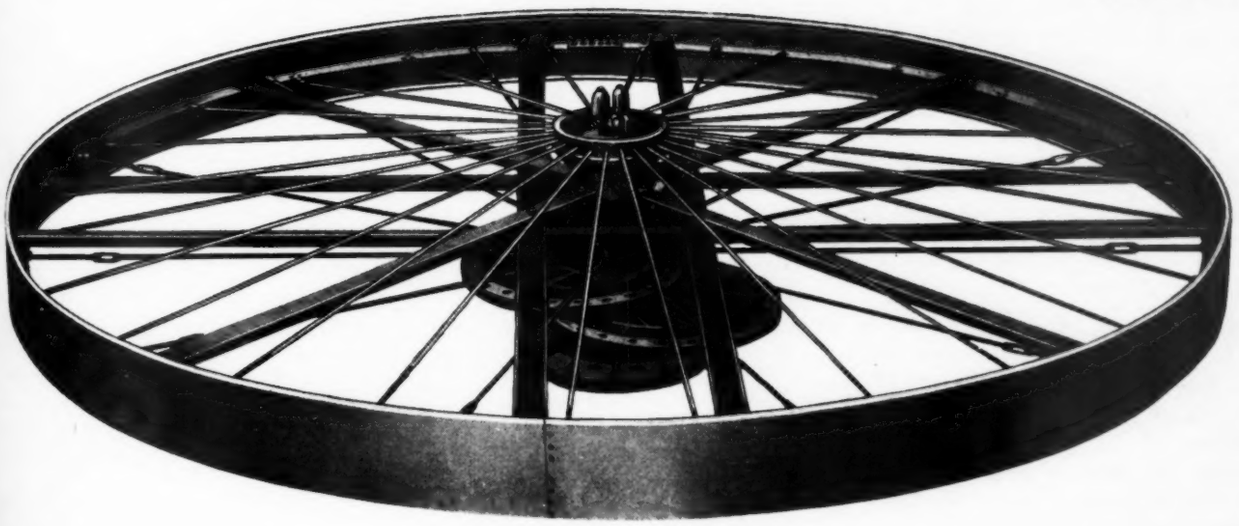
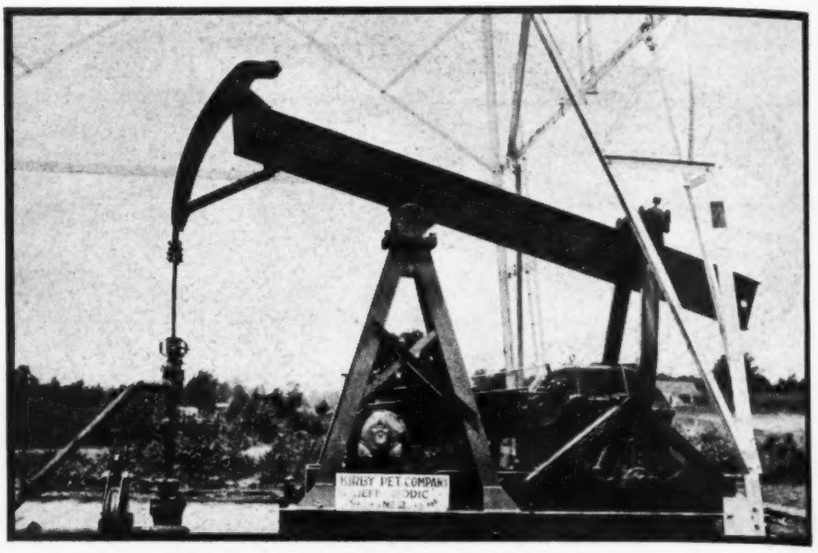


THE NATIONAL SUPPLY COMPANIES

Determining Size of Electric Pumping Equipment

IT has been pointed out by several writers in recent articles that it will require careful management to make many East Texas oil properties pay out and show a net profit in the end. Now that the pumping stage is near it appears that the final outcome will depend largely on the method used in lifting the oil and the economy exercised in equipping the wells. It does not necessarily follow that the system that will recover the greatest amount of fluid will produce the largest dividends. The idea that it is unsafe to install anything but the heaviest equipment on the market seems to be somewhat overworked. Frequently, extra production procured by over-equipping oil fields or overtaxing light equipment is obtained at a loss. There is a tendency for many engineers to lose sight of the fact that the object of producing oil is to make money by showing a profit in producing operations.



Motor-driven twin-crank pumping unit on East Texas well

To the major operators East Texas is just another oil field. They are able to purchase heavy equipment with the thought in mind of moving it to new fields after East Texas has been abandoned. Many small operators cannot afford to do this; they must equip their wells at as small an initial outlay as possible and their operating expenses must be reduced to a minimum in order for them to survive. It seems that the wisest thing for those so situated to do is to forget such things as "potentials," fix a reasonable limit to the amount of fluid they can afford to handle and equip their wells accordingly. Establishing no limits and forsaking fundamental principles in selecting equipment often leads to absurd conclusions, as is illustrated by the following incident:

Some time ago a salesman for an equipment company obtained an order from a small producer for a unit to be used for pumping duty only, equipped with a 40-hp. electric motor. A few minutes later the purchaser met a representative of the power company serving the territory in which the unit was to be used and asked him what the monthly power bill would be. The power salesman tore a leaf from his note book and proceeded to submit calculations that were about as follows:

$(40 \times 746 \times 24 \times 31)/.90$ (motor efficiency) $\times 1000$
$= 24660$ kw-hp. per month

24660 @ 1¾c (estimated) = $431.00.

Needless to state, the order was canceled within a few minutes.

Now the producer, although not an engineer, was familiar with gas engine practice. He knew that it is the custom to equip wells with engines having a much higher nominal horsepower rating than needed to carry the actual load and it was natural for him to follow the same line of reasoning in selecting a unit. The equipment salesman had been taught that "The customer is always right" and made only a feeble attempt to point out the fallacy. Unfortunately, the power salesman based his calculations on a 100 per cent load factor and did not realize that it is worse than useless to offer a rate that, for pumping cheap oil, is prohibitive.

When selected with proper care, equipment involved in pumping with electricity has a low initial cost, and operators contemplating its use should analyze their pumping problems with great care, for the electric motor offers an extremely wide range of capacities and speeds. Jumping at conclusions, as in the instance cited above, leads to many costly errors.

In determining the size of the equipment required to pump such wells as are found in East Texas it is evident that the nature of the fluid, the gas conditions, the fluid level and the size of the tubing are the limiting factors. It has been said by experienced operators that 700 or 800 bbl. of fluid is the maximum amount one can expect to pump economically through 2½-in. tubing, with which most of the wells are equipped. Doubtless more than this can be lifted but it is questionable whether it will be profitable to do so, as no one has as yet offered a satisfactory solution to the problem of salt water disposal.

Table 1 gives the theoretical horsepower required to lift a given quantity of fluid whose weight is equivalent to that of fresh water. The work done in lifting a barrel of clean oil with a gravity of 40-deg. A.P.I. is about 80 per cent of that given in the table, while that expended in lifting salt water will be somewhat greater.

A study of the table will show that a surprisingly small amount of power is required to do the useful work on a pumping well. For example, a 20-bbl. well with a 3500-ft. fluid level when operated continuously, needs only ½ hp. to accomplish the useful work. Were a rig provided that is

Forsaking basic principles in selecting motors may lead to costly errors

for East Texas

« By W. C. LANE
Electrical Engineer »

only 25 per cent efficient, a 2-hp. motor would be ample. A 75-bbl. well with the same fluid level represents 1.92 hp. so that a 5-hp. motor should suffice. A 10-hp. motor should lift 300 bbl. from the 2500-ft. fluid level if the losses between the motor and the bottom of the well are kept within reasonable limits. The theoretical horsepower required to lift 750 bbl. of fluid 3600 ft. is approximately 20. Assuming an overall efficiency of 50 per cent for the pumping rig (and where is the supply salesman who will admit that his offering is that low?) it follows that 40 hp. is the capacity of the heaviest unit required. Since it is improbable that the greatest amount of fluid will ever be produced when the fluid level is at the bottom of the well it is reasonable to think that the actual maximum power requirements will be much less than this.

It appears that many prospective users of electric power do not understand that the rating of an electric motor is based on the constant load it will carry day after day for an indefinite time. Temperature and an excessive drop in speed are the usual load limiting factors. Few motors used for pumping will actually stop when a 50 per cent overload is thrown on them but, of course, they will burn out if such loads are applied continuously. For these reasons a well that actually requires a 40-hp. gas engine for pumping only will not require an electric motor of the same rating. The practice of over-motoring is bad and should be avoided by the user and discouraged by both the power company and the equipment salesman. The first cost of an electric motor is a matter of minor importance as compared with the evils of lower efficiency, lower power factor, and the resultant power bills that are higher than they should be.

Since the useful work done in pumping a well is small it is evident that the most important thing is to provide a rig set-up that is efficient at all loads and remains in adjustment. The combined weight for the string of rods and that of the fluid column to be lifted, including friction, differs but little on wells of a moderate capacity and on those with a small production, so that the same sampson post, walking beam, pitman structure, should be used for both. On numerous occasions the writer has found that reported cases of motors being overloaded could be remedied by tightening up a jack-post bearing, straightening up the sampson post, or altering the counterbalance. Such experiences have led to the conclusion that the economic operation of motor-driven pumping units depends more on that part of the pumping mechanism found between the low-speed shaft and the polish rod than anything else.

Inasmuch as two of the factors in an electric power rate are based on load factor and the maximum power demand, it follows that any system of pumping adopted should include provisions for reducing these two quantities to a minimum. This can be accomplished in two ways—by adjusting the speed, stroke and pump sizes so that each well will operate at the highest possible overall efficiency throughout the day or by operating the wells intermittently on a schedule such that the total power demand will remain as nearly constant as is possible. Such a schedule can be carried out by starting the wells either manually or by the use of time clocks.

Over-motoring may be avoided by purchasing two or three sizes of single-rated motors having universal bases so that they can be moved from one well to another, or by the use of multiple-rated motors. Obviously, the latter method incurs the greater first cost. In case it should develop during the early pumping stage that all motors are lightly loaded, efficiencies can be improved by reducing the operating voltages. This can be done by changing the taps on the transformers that supply energy to the lease. The universal custom of operating oilfield motors at an over-voltage increases motor losses unnecessarily.

It will be found that favorable electric pumping costs can be procured providing reasonable care is exercised in selecting the equipment and in operating it so as to avoid an unnecessary expenditure of electrical energy.

TABLE I

Theoretical horsepower required to lift a fluid whose weight is equivalent to that of fresh water.

	HORSEPOWER REQUIRED													
Height lifted in ft.	Quantity lifted in bbl.													
	10	25	50	75	100	200	300	400	500	600	700	800	900	1000
100	.007	.02	.04	.06	.07	.14	.21	.28	.36	.43	.50	.57	.65	.72
200	.015	.04	.07	.11	.15	.29	.45	.60	.75	.90	1.1	1.2	1.4	1.5
300	.022	.06	.11	.17	.22	.44	.66	.88	1.1	1.3	1.5	1.8	2.0	2.2
400	.030	.07	.15	.22	.30	.60	.90	1.2	1.5	1.8	2.1	2.4	2.7	3.0
500	.037	.09	.18	.28	.36	.74	1.1	1.5	1.8	2.2	2.5	2.9	3.2	3.6
1000	.073	.18	.37	.55	.74	1.5	2.2	2.9	3.6	4.3	5.0	5.8	6.5	7.4
1500	.110	.28	.55	.83	1.1	2.2	2.3	4.4	5.4	6.5	7.6	8.6	9.7	11.0
2000	.146	.36	.73	1.1	1.5	2.9	4.4	5.8	7.2	8.6	10.0	11.5	12.9	14.6
2500	.184	.46	.92	1.4	1.8	3.7	5.5	7.4	9.2	11.0	12.8	14.7	16.6	18.4
3000	.220	.55	1.1	1.7	2.2	4.4	6.6	8.8	11.0	13.2	15.4	17.6	19.8	22.0
3100	.230	.57	1.1	1.7	2.3	4.5	6.8	9.1	11.4	13.6	15.9	18.2	20.5	22 7
3200	.230	.59	1.2	1.8	2.3	4.7	7.0	9.4	11.7	14.1	16.5	18.8	21.2	23.5
3300	.240	.60	1.2	1.8	2.4	4.8	7.2	9.7	12.1	14.5	17.0	19.4	21.8	24.2
3400	.250	.62	1.3	1.9	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0
3500	.256	.64	1.3	1.9	2 5	5.1	7.7	10.2	12.8	15.4	17.9	20.5	23.0	25.6
3600	.260	.66	1.3	2.0	2.6	5.3	7.9	10.5	13.2	15.8	18.4	21.1	23.7	26.3
4000	.292	.73	1.5	2.2	2.9	5.8	8.8	11.7	14.4	17.5	20.4	23.4	26.3	29.2

Research suggests methods of obtaining lubricants of high-pressure stability

Extreme Lubri

as required by new auto

IT was just a few years ago that the automotive engineer improved the compression ratio of the internal combustion engine and by doing so, forced the refiner to change entirely the quality and nature of the motor fuel. The refiner had to develop the anti-knock motor fuel in order to meet these new conditions, and he certainly solved the problem very well. Ethyl gasoline and the high-octane anti-knock gasolines were the result.

The automotive engineers then turned their attention to the power transmission of the automobiles and by improving and changing it, achieved appreciable mechanical advantages. They designed and developed the hypoid- and worm-gear drives for modern automobile transmisison. This new type of assembly gives much more efficient power transmission; it permits the car designer to build the car lower on the chassis, lowering the center of gravity and thus increasing the safety factor. The design of these new gears is such that the rubbing speed and pressure per unit of tooth area is much greater than with the older type gear in use in automotive vehicles. These units could not be satisfactorily lubricated with ordinary transmission oils, like 600-W. The automotive industry needed a new lubricant for this new type of transmission assembly, which the newly designed gears, with their increased and extremely high tooth pressure demanded; in other words, the automotive industry required an extreme-pressure lubricant to make the new gear assembly a success.

The refiner or lubricant manufacturer turned this problem over to his research staff. Considerable pioneering work had to be done before the actual solving of the problem could be tackled, as very little was known about E.P. (extreme-pressure) lubricants in general and how they actually functioned. On the whole very little literature was available on this subject.

We are accustomed to think of lubrication as a condition in which a film of oil prevents the rubbing surfaces from coming into contact with another, and thus prevents wear and reduces friction. That this condition actually exists in well-lubricated bearings was a well-known fact and had been studied frequently and thoroughly, but it was not so well understood why this conception of lubrication did not apply to gears under heavy load, such as existed in the newly designed transmission assembly. The difference is this: in a well-lubricated bearing the loads very seldom exceed 2000 lb. per sq. in. and the rubbing speeds are generally high enough to maintain a protective oil film that separates bearing and journal. In the new automotive transmission assembly we have entirely different conditions; the tooth pressure is enormously high and the rubbing speed is comparatively low, both of which are factors that make the selection of a proper lubricant a very difficult problem. On top of that, the shape of the gears with their convex curvatures was a great obstacle in maintaining a lubricating film. It was obvious that ordinary viscous oils or greases could not be used as efficient transmission lubricants, as a protective film could not be maintained under these conditions, especially where operating temperatures of 210 deg. fahr. and greater were not unusual.

The first step forward was the construction of some kind of testing equipment to enable the research engineer and chemist to study the pressure stability of lubricants under these new operating conditions. Very complicated and expensive machines were designed and built; whole rear axle assemblies were made and the behavior of lubricants studied at increased pressure and decreased rubbing speed.

During the early stage of the experimental work it was found that, if a lubricant could be developed that would form on the surface of the steel bearing a film or plate with a low coefficient of friction, similar in effect to that of the film or plate of electro deposited metal, and that if this film or plate could be reformed automatically as it is worn off in service, it might be a solution of the problem. Everything seemed to indicate that this was the way the E.P. lubricants should function.

For a number of years lead-soap lubricants have had the reputation of being able to carry higher loads than ordinary mineral oil lubricants. Therefore, it was the most logical step to examine lubricants of this type first. It was found that some lead-soap lubricants had this superior load-carrying ability and that others did not. In trying to determine the reason for this difference it was found that the presence of large amounts of sulphur in the successful lead-soap lubricants was responsible for their higher load-carrying power. This, together with the knowledge that flowers of sulphur had long been used to overcome overheated bearings and that sulphurized oils were used extensively as cutting oils, suggested that the sulphur was the active ingredient in the successful lead-soap lubricants. Numerous experiments were made and it was found that lead-soaps added to sulphur-free mineral oil did not seem to increase the load-carrying power of the same, but lead-soaps added to mineral oils containing sufficient sulphur produced an E.P. lubricant. During the testing of these lubricants it was found that the surfaces of the steel bearings were covered with a black film, which proved to be iron sulphide. This investigation indicated that the superior load-carrying properties of E.P. lubricants were due to the formation of a separating film, not of oil, but of some material formed directly on the surface of the steel.

If this assumption was correct, it would be necessary for an oil to contain chemically active materials in order to function as an E.P. lubricant and it seemed likely that other chemicals than sulphur should have the same properties. The General Motors Corp., the Timken Roller Bearing Co., and a good many other concerns did considerable work in this connection and after examining hundreds of different chemical compounds, they found that chlorine, in various forms, has a very pronounced ability to increase the load-carrying property of lubricants. Such compounds as carbontetrachloride, dichlorethylether, etc., in quantities from one per cent up proved very efficient. The action of these chlorine com-

Pressure
icants

mobile gear transmissions

By DR. W. T. SIEBER
Chief Chemist for
Waverly Oil Works
Company, Pittsburgh

pounds is based on the formation of iron chloride on the bearing surfaces, which apparently acts as a separating film capable of sustaining extreme loads. Furthermore, it was proven that the viscosity of the lubricating oil is of little importance as regards its load-carrying ability in the region of extreme pressure.

In summarizing the results of the research work, we find that the characteristics of an ideal extreme-pressure lubricant should be as follows:

1. The extreme-pressure ingredient should be combined with the oil with such chemical stability that it will not cause corrosion under any condition, except that occasioned by unit pressure above the film-carrying capacity of the oil itself.

2. The oil should possess the maximum film strength so that the extreme-pressure constituent may remain chemically inert the greatest possible percentage of operating time.

3. The stability of the lubricant must be such that it can be stored indefinitely without deterioration in any degree.

4. The cost must not be excessive.

5. The extreme-pressure lubricant should have a pressure stability of at least 25,000 lb. per sq. in. in order to assure positive protection against galling and scoring.

Based on these results, worked out by the research engineer and chemist, it was now left to the lubricant manufacturer to select the best and most suitable combination in manufacturing a product that would meet the requirements of an extreme-pressure lubricant and at the same time would stand competition. There are several possibilities and combinations that all lead to practically the same results; naturally the finished products differ somewhat in their physical properties and with regard to degree of pressure stability.

In general, lubricants of the extreme-pressure type can be classified into three groups:

1. Blends of petroleum oil with a saponifiable oil that has been treated with sulphur chloride, thus combining in one compound the two elements showing the best results.

2. Blends of petroleum oil with a saponifiable oil to which has been added elementary sulphur.

3. Lead-soap lubricants to which sulphur has been added or in which sulphur occurs native in the petroleum oil used.

Raw materials used in the manufacture of extreme-pressure lubricants are usually fatty oils of animal origin, like lard oil, fish oil, etc., but vegetal oils can also be used. In sulphurizing these fatty compounds great care must be exercised in order to combine the sulphur or chlorine in the right way, so as to obtain the maximum pressure stability with minimum corrosion.

Using sulphur chloride as sulphurizing and chlorinating agent it is not so hard to accomplish the desired result, as sulphur chloride reacts very readily and the operation must be carried out at comparatively low temperature. The main obstacle, however, is to free the finished compound from any hydrochloric acid formed during the reaction, as otherwise very corrosive compounds are obtained.

As sulphur chloride itself is hard to handle on account of its chemical nature, only a limited number of lubricant manufacturers are using this compound.

The most common way of making sulphur oil is by the use of a saponifiable oil and flowers of sulphur at elevated temperatures. Great care has to be taken in combining the sulphur chemically with the saponifiable oil, which requires comparatively high temperatures and considerable time. Hydrogen sulphide gas is liberated very freely and equipment with very efficient ventilation has to be used.

It is not necessary to elaborate on the manufacture of lead-soaps, as this is pretty well understood. Two methods are in use; the method of double decomposition, and the fusion method, the latter being employed quite extensively.

One factor should be mentioned; that is, in order to obtain maximum pressure stability it is necessary to incorporate the lead-soaps with the mineral oil at temperatures around 400 deg. fahrenheit.

With regard to the mineral oil used in the manufacture of extreme-pressure lubricants it is hard to set any specifications, as the manufacturer is mostly guided by conditions and price. A good many grease makers prefer Pennsylvania cylinder stock, some use Western residuums, and the author knows of at least one manufacturer who is using an overhead distillate of high viscosity. One thing, however, the manufacturer should always bear in mind is, to use well-refined oils, as the danger of oxidation in poorly-refined oils is great and an increase in viscosity and consistency of the lubricant will result and will make the lubricant unfit for use.

By proper manufacture and compounded at the right temperature the evil of corrosion can easily be overcome.

Extreme-pressure lubricants for transmission and differential use are usually made in three consistencies: SAE-90; SAE-110; and SAE-160; and should have a comparatively good pour test.

In conclusion, brief mention should be made of the testing equipment that is used at the present time to determine the value and to measure the pressure stability of extreme-pressure lubricants. There are three machines in use, each one of which has its advantages and disadvantages, which will not be discussed here. These three machines are: the General Motors testing machine (Allman machine); the Floyd testing machine; and the Timken wear-testing machine. However, from tests performed in the writer's laboratory it can be said that there is apparently no correlation of results between these three types. For example, an extreme-pressure lubricant that withstood 45000-lb. pressure on the Timken testing machine, showed only about 22000-lb. pressure stability on the Allman machine. In short, there is still much to be done, before we will have the ideal extreme-pressure lubricant.

Checking Gas Booster Plant Operation With Temperature Gauges

Thermometer readings indicate compressor efficiency

By
WARREN L. BAKER

THE use of natural gas as both a domestic and industrial fuel has been tremendously stimulated by the construction and extension of pipe line facilities that make it available not only to districts in the immediate producing area, but also to cities or communities 1000 miles or more distant from the source of supply. From an inauspicious beginning, which first found expression in the early 2-in. and 3-in. transmission lines of 10 or 12 miles in length, pipe line gas transportation systems have grown by leaps and bounds. Today there are lines 18, 20, 24 and 26 in. in diameter through which gas is supplied to distant cities.

Since pressure is fundamental in the transportation, or delivery, of natural gas, its close control is vital from the time the gas is taken from the well until it is piped to the burner of the consumer. In many fields, the natural well pressure, which if too high may be reduced to a convenient working pressure, is sufficient to send the gas through the gasoline plant and the transmission system to the various points of consumption or use in proximity to the area of production. However, in utilizing low-pressure residue gas from gasoline plants or from the wells direct for long-distance transportation, it becomes necessary to boost the pressure to maintain the desired flow. This is accomplished by the compressor, which virtually pumps the gas through the pipe line.

The whole fabric of long-distance transportation depends on the proper functioning of the compressor plant. In this vital factor in the general scheme of gas transmission, each plant must be thoroughly manned and scientifically operated and controlled. Efficient operation may be made possible by the application of instruments for the measurement and control of temperatures and pressures. Because of its influence on compressor operation, temperature alone will be considered in this article.

A knowledge of compressor gas inlet and discharge temperatures is necessary in order to determine whether each compressor is efficiently doing its part. When operating conditions are definitely established, there ordinarily is a fixed differential between suction and discharge temperatures. A low discharge temperature indicates that that particular compressor is not handling its proper quantity of gas, whereas a high discharge temperature indicates that the gas is receiving heat from some extraneous source, probably from leaky safety heads, discharge valves, or pistons. Discharge temperatures can mount without the defect in the compressor being noticeable as far as the noise is concerned. The installation of thermometers in compressor suction and discharge lines affords a practical and efficient gauge of compressor performance.

Since defective conditions in the operation of compressors are reflected in part by the temperature of the cooling water, thermometers for indicating the temperature of the cooling water from the cylinder jacket and from the pistons are of definite value in determining the mechanical condition of the compressor as well as the efficiency of the water circulating system.

These thermometers may be equipped with an electric temperature contact, which can be set to sound an alarm when any predetermined, or dangerous, temperature is reached. This application is of particular benefit at stations where a large number of compressors are in service in that such installations eliminate the necessity for complete dependence on the periodic observations of the operator.

If it is desired to carry scientific control of gas booster plants further, besides the set of thermometers thus equipped, the use of certain instruments on the market may be adopted that will indicate temperatures of the engine bearings, and recording pressure gauges may be employed to record suction and discharge pressures in the case of individual compressors or pressures in the plant suction or discharge headers.

Because of its effect on the smoothness and consistency of pressure regulation and accuracy in flow measurement, the presence of moisture or water in transmission lines is highly objectionable. Moisture in gas lines is also undesirable because of its possible freezing in the regulator and meter lines, and the high humidities attendant on its combustion in the home. It is desirable, therefore, to liquefy and remove as much moisture as possible at the compressor station before the gas passes into the transmission lines.

The temperature to which the gas is cooled after it leaves the compressors determine in part the amount of moisture that has been removed and the temperature at which condensate will begin to form in the lines. The lower the temperature of the gas from a given condition of saturation at the booster station, the lower will be the temperature at which water will form in transmission and vice versa.

Thermometers are of definite service in determining and maintaining the desired conditions of cooling when installed to indicate the temperatures of gas from after-coolers. Thermometers are similarly applicable in the water line from after-coolers.

It is desirable that all the information collected by the use of the above instruments be compiled and correlated in a general log of plant operation, if a careful check is to be maintained on the efficiency of the station. Today there are on the market three-pen recording thermometers that are successful in recording compressor gas suction temperatures, gas discharge temperatures and the temperatures of the gas from the after-coolers on a single chart. By this means may be obtained a logical presentation of correlated data, which, if carefully studied, will prove of material benefit in aiding the station operator to determine the operating efficiency of his compressors.

Film Coefficients of Heat Transfer

« Article 1 »

In this series of two articles the author presents a method for determining film viscosities for heating and cooling conditions. Using this method the data of Morris and Whitman were correlated and a closer relation was found.

By WAYNE C. EDMISTER
Research Engineer

A FLUID flowing in a tube forms a film that adheres to the tube wall, the thickness and velocity of which depend on the fluid and conditions of flow, be they viscous or turbulent. This film offers one of the most important resistances to the flow of heat.

The equation for heat flow is:

$$Q/\theta = A\,H\,\Delta T \quad . \quad . \quad . \quad . \quad (1)$$

The overall coefficient, H, is the reciprocal of the overall resistance to the flow of heat, which is the summation of all component resistances, as they are in series. These resistances, for simplicity, are based on the area, A, at either the outer or inner surface of the tube. Basing the coefficients on the inner area, A_1:

$$1/H_1 = 1/h_1 + (r_1/kt)\log_e(r_2/r_1) + (1/h_2)(r_1/r_2) \quad . \quad (2a)$$

and basing the coefficients on the outer area, A_2:

$$1/H_2 = 1/h_2 + (r_2/kt)\log_e(r_2/r_1) + (1/h_1)(r_2/r_1) \quad . \quad (2b)$$

Equation 1 becomes:

$$Q/\theta = A_1H_1\,\Delta T \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1a)$$

$$Q/\theta = A_2H_2\,\Delta T \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1b)$$

Equations (1a) and (2a) are used together, and equations (1b) and (2b) are also used together, according to the problem.

The film concept for heat transfer seems to have been generally accepted and it is commonly recognized that for a fluid flowing in a pipe where heat is being transferred mainly by forced convection to or from the fluid, the film coefficients and other factors that determine the rate of flow of heat may be correlated by means of three dimensionless groups. These groups are the Nusselt number, hD/k; the Prandtl number, CZ/k; and the Reynolds number, which is proportional to DVS/Z. Their relation, which can be found by dimensional analysis, is:

$$hD/k = a(DVS/Z)^m(CZ/k)^n \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where *a*, *m*, and *n* are constants and may depend upon the condition of flow, i.e., viscous or turbulent, and upon heating or cooling conditions as well as upon the type of fluid under consideration.

When C, Z, and k were taken at the average body temperature, which is the common practice, it has been found that *a* for cooling is about 0.75 the value for heating. For heavier, more viscous oils being heated by high-pressure steam, for example, equation (3) will not give the correct film coefficient unless the constants are again changed.

The discrepancy appears to be due to the failure to take into account the fact that the viscosity as used at the average temperature of the body of the fluid is not the true average viscosity of the film of the fluid directly involved in heat transfer. When heat is being transferred to the fluid, the film is at a temperature appreciably higher than the average temperature of the body of the fluid, and when heat is being transferred from the fluid, the film is at a temperature appreciably lower than the average temperature of the body of the fluid. The amount the film temperature is above or below the average body temperature depends on the characteristics of the fluid, the heating or cooling medium, and the rate of transfer of heat. There have been attempts to formulate the relation between the film temperature and the body temperature for heating and cooling but they have been only a guess as to what temperature between the body temperature and the wall temperature should be chosen as the film temperature.

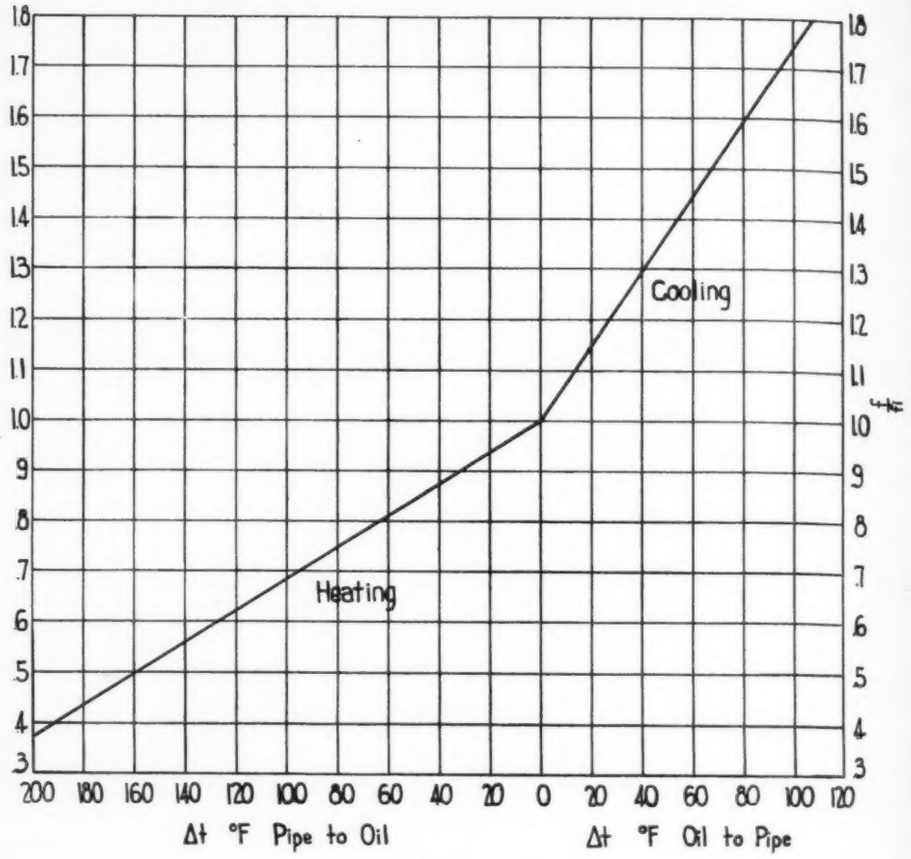
It is known that fluid flow and heat transfer are closely related and the author has attempted in this paper to find that relation, using the best experimental data available.

Viscosity Correction. The specific heat, C, and the thermal conductivity, k, of the fluid are taken at the main body temperature and may be readily found from tables of physical data, hence little attention need be given to them here. The value of the viscosity, Z, however, will be corrected from its value at the main body temperature to a value that is necessary to satisfy the flow conditions of the Fanning formula. For isothermal flow the flow viscosity is the main body viscosity and so will be called Z*i*. For heating, on the other hand, the flow viscosity is lower than the main body viscosity or $Zi > Zb$, while for cooling, the flow viscosity is higher, or $Zi < Zc$.

Keevil and McAdams[1] investigated the manner in which heat transfer affected fluid friction in pipes for both heating and cooling, using oil, water, and air. Fig. 1 represents their results for viscous flow, where the abcissa indicate the temperature drop in deg. fahr. from the oil to the pipe for cooling and from the pipe to the oil for heating. The ordinate is f/fi, in which f is the friction factor for the prevailing condition of flow and *fi* is the friction factor for isothermal flow.

[1]Chem. and Met., Vol. 36, 1929, p. 464.

Fig. 1



The viscosity correction for heating and cooling will be treated separately.

Heating. The equation for the Keevil and McAdams' line for heating is:

$$fh/fi = 1 - 0.0032\ \Delta t \quad . \quad (4a)$$

From a consideration of equation (1) it follows that:

$$H\Delta H = h\Delta t \quad . \quad . \quad . \quad . \quad (5)$$

Eliminating Δt from the equations (4a) and (5) and solving for fh, the following expression for fh is obtained:

$$fh = fi\ [1 - 0.0032\ (H/h)\ \Delta T] \quad . \quad . \quad . \quad . \quad . \quad (6a)$$

As the other factors remain practically the same for heating as for isothermal flow, it is safe to say that the change in the friction factor, f, is due entirely to the change in the viscosity, that is:

$$Zh = Zi\ [1 - 0.0032\ (H/h)\ \Delta T] \quad . \quad . \quad . \quad . \quad . \quad (7a)$$

Cooling. The equation for the Keevil and McAdams' line for cooling is:

$$fc/fi = 1 + 0.0074\ \Delta t \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4b)$$

On eliminating Δt between equations (4b) and (5), fc is found to be:

$$fc = fi\ [1 + 0.0074\ (H/h)\ \Delta T] \quad . \quad . \quad . \quad . \quad . \quad (6b)$$

The change in the friction factor for cooling will also be due to the change in viscosity, that is:

$$Zc = Zi\ [1 + 0.0074\ (H/h)\ \Delta T] \quad . \quad . \quad . \quad . \quad (7b)$$

The value of the slopes of the Keevil and McAdams' line will depend on the type of viscosity curve the fluid in question has. If, for example, a fluid whose viscosity does not change with temperature is being considered, the slope of the Keevil and McAdams' line will be zero and the viscosity for heating and cooling will be the same as for isothermal flow. For oils, water, and fluids common to engineering practice the slopes 0.0032 for heating and 0.0074 for cooling are accurate enough for design calculations.

The viscosity corrections expressed in (7a) and (7b) are for viscous flow only. In using them for turbulent flow and for correlating film coefficients, the author is making a very broad assumption, which may or may not be justified by experimental data.

Data and Calculations. The most complete experimental data for film coefficients available are those of Morris and Whitman[2], and even these are unsatisfactory because only one size tube was used and no heavy oils were tested. The data are for four series of heating runs and for three series of cooling runs, using atmospheric steam as heating medium and water as cooling medium. The fluids tested were water, gas oil, straw oil, and light motor oil. The readings taken were the tube size, mass velocity of the fluid in the tube, inlet and outlet temperatures of both heated and cooled fluid, external temperature of the tube at the center of the heating section, and the total heat transferred. The flow was counter current.

Knowing the sum of the temperature drops across the inside film and the tube wall as well as the resistance of the tube wall, and basing the calculations on the inside area, A_1, the value of the film coefficient as well as the overall coefficient is found for each run. The viscosities at the average body temperatures are found from physical data on the fluid and are corrected to the flow viscosities for heating or cooling by means of equations (7a) or (7b). The specific heats, C, and the thermal conductivities, k, for the fluid are also found from physical data. With these values of C, Z, and k and values of D, V, S and h, the three dimensionless groups are calculated.

The value of the exponent, n, in equation (3) is found to be 0.4. Values of:

$$(hD/k)/(CZ/k)^{0.4}$$

were plotted against Reynolds' number or 7737.6 DVS/Z in Fig. 2.

Results and Conclusions. Fig. 2 shows very clearly the existence of a critical region, which is approximately between the same values of Reynolds' number at which the critical flow condition is found. It is also noted that the lines for viscous and turbulent flow have different slopes. The close correlation of all data and the fact that heating and cooling data fall on the same curves seem to justify the original assumption that the viscous flow viscosity correction may be applied to the correlation of film coefficients for both viscous and turbulent flow.

The fact that the film coefficients for both heating and cooling may be found from Fig. 2 without multiplying the

[2] J. Ind. and Eng. Chem., March, 1928.

film coefficient for heating by 0.75 to get the film coefficient for cooling as Morris and Whitman do, indicates that this method of correlating the data is more reliable than the one the original authors used.

More data should be made available, however, so as to check the results of Fig. 2. These data should be from experiments on heavy oils, light gasolines, residues, gases and vapors, using various size pipes and various heating and cooling media.

It is hoped that Fig. 2 will be useful in determining film coefficients for heat transfer and that it will throw some light on the correlation of such data.

Nomenclature:

D = inside diameter of tube in inches.

V = fluid velocity in ft. per sec. (average).

S = specific gravity of the fluid (water = 1).

Z = absolute viscosity of flow in centipoises.

C = specific heat of the fluid at constant pressure.

Q/θ = quantity of heat flowing in B.t.u. per hour.

A = area of heating surface in sq. feet.

H = overall heat transfer coefficient in B.t.u./hr./sq. ft./°F.

Δt = temperature drop across the film in °F.

ΔT = mean temperature drop from one fluid to the other in °F.

r = radius of tube in inches.

Subscripts 1 and 2 when applied to H, h, A, or r refer to the inner and outer surface, respectively.

k_t = thermal conductivity of the tube wall in B.t.u./hr./sq. ft./in/°F.

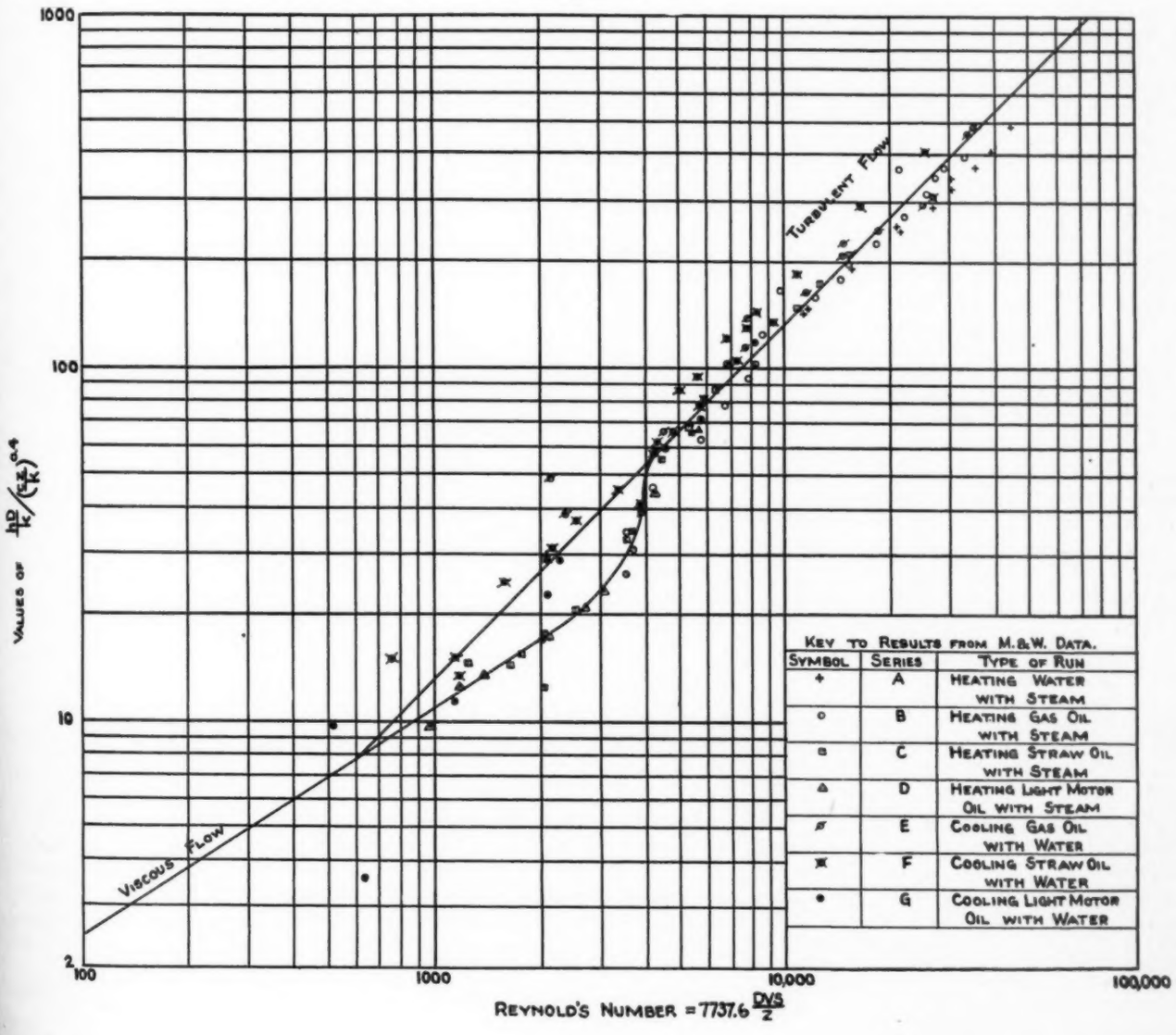
k = thermal conductivity of fluid in B.t.u./hr./sq. ft./in./°F.

h = film coefficient in B.t.u./hr./sq. ft./°F.
a, m, and n are constants.

f = friction factor.
Subscript *i* when applied to f and Z refers to isothermal condition.
Subscripts *b* and *c* when applied to f and Z refer to heating and cooling conditions, respectively.

Article II of this series, which presents a new chart for film coefficients and friction factors for heat transfer, will appear in the October issue.

Fig. 2


1000
100
10
2
100
1000
10,000
100,000
VALUES OF $\frac{hD}{k}/(\frac{DVS}{Z})^{0.4}$
REYNOLD'S NUMBER = $7737.6\frac{DVS}{Z}$
TURBULENT FLOW
VISCOUS FLOW
KEY TO RESULTS FROM M.&W. DATA.
SYMBOL | SERIES | TYPE OF RUN
+ | A | HEATING WATER WITH STEAM
○ | B | HEATING GAS OIL WITH STEAM
□ | C | HEATING STRAW OIL WITH STEAM
△ | D | HEATING LIGHT MOTOR OIL WITH STEAM
⌀ | E | COOLING GAS OIL WITH WATER
✱ | F | COOLING STRAW OIL WITH WATER
• | G | COOLING LIGHT MOTOR OIL WITH WATER

The Hypochlorite Process For Treating Natural Gasoline

By
KENNETH S. RITCHIE
Consulting Engineer

A SHARP decrease in the consumption of chlorine was noticed during an unprecedented spell of comparatively severe cold weather several years ago. It was evident that an unexpected factor had affected the normal chemical reaction of sodium hypochlorite for the mercaptan-bearing hydrocarbons. Substantial savings in the bill for chlorine were indicated if the basic principle for this decrease in chlorine consumption could be definitely found and treating plant conditions maintained accordingly throughout the year. Thus, quite an extended series of observations on this phenomenon were subsequently made. The data and the results of this investigation are presented herewith, including several of the theories used to explain the phenomenon.

Chemistry of the Process. A brief summary of the principal chemical reactions occurring in the hypochlorite process of treating is presented in order to help the reader have a better understanding of the data and the results given later.

Birch[1] of the Anglo-Persian Oil Co.—the company that developed this process for practical use—has given the clearest explanation of the chemistry of the process published to date.

The first important chemical reaction to take place is the removal of the hydrogen sulphide (H_2S), usually by contacting with partially spent aqueous caustic soda (NaOH) or lime ($Ca(OH)_2$) solutions to form sodium sulphide (Na_2S) or sodium hydrogen sulphide (NaHS) or the corresponding calcium compounds if a lime solution is used. The reaction products remain with the wash solution, thereby removing that much of the sulphur content of the gasoline from it. This reaction may be expresesd by the following equations:

$$\left.\begin{aligned} H_2S + 2\,NaOH &\rightarrow Na_2S + 2\,H_2O \\ H_2S + \;\;NaOH &\rightarrow NaHS + H_2O \end{aligned}\right\} \quad . \; . \; . \; . \quad (1)$$

The second important chemical reaction to take place is the partial removal of the mercaptans (RSH) and other acidic organic sulphur derivatives, designated by the presence of an .SH group, which gives a positive reaction to the "doctor" test, by contacting with the aqueous caustic or lime wash solutions. This partial removal of the mercaptans is effected in two general steps, as follows:

1. The formation of sodium mercaptide (RSNa) is a reversible reaction,

$$RSH + NaOH \rightleftarrows RSNa + H_2O \quad . \; . \; . \; . \quad (2)$$

which stops as soon as the concentration of the free mercaptans in the gasoline balances the concentration of the mercaptans, including the sodium mercaptides in the aqueous caustic solution. In addition to the evidence represented by this reaction that complete removal of the mercaptans is not possible, there is a rapidly decreasing tendency for the reaction to go from left to right as the molecular weights of the hydrocarbon "R" are increased. (See table in Birch's article).

2. The concentration of the aqueous caustic solution has a greater effect on the mercaptan removal than is generally realized. It has been clearly demonstrated[2] and subsequently used as a part of regular treating plant operation that the more dilute solutions of the same weight of caustic soda removed more of the mercaptans than solutions of the usual concentration. Best results were obtained practically at the plant with a caustic solution of seven deg. Baumé.

Birch's explanation, which is the best, for this surprising fact is summarized as follows: Addition of water to the system in Equation (2) disturbs the balance and displaces the equilibrium point to the left, that is, some of the sodium mercaptide (RSNa) is hydrolyzed to form more free mercaptans and establish a new balance. If this system of water, sodium mercaptide, caustic soda and marcaptan is diluted, for example, to twice its volume, the quantity of free mercaptan in the aqeuous solution will not be doubled but will be increased by some smaller amount and thus the concentration of the free mercaptan in the diluted aqueous solution will be less than before. But if the aqueous solution containing (among other substances) mercaptans is in contact with a petroleum solution (gasoline) also containing mercaptans, there is a constant partition coefficient existing that must be satisfied; i. e.

$$\frac{\text{Conc. RSH (oil)}}{\text{Conc. RSH (water)}} = K$$

this is *solely dependent on the solubility of the mercaptan in the oil and in the water* and is entirely independent of the presence of other substances. If, therefore, the aqueous solution is diluted and the concentration of free mercaptan therein decreased, more mercaptan must pass from the oil to the water to maintain the value of the constant partition coefficient.

Thus, the efficiency of a given weight of aqueous caustic soda for removing a mercaptan from petroleum solution (gasoline) is greater the lower the concentration at which it is employed.

The third and final important chemical reaction is the removal of the remainder of the mercaptans and other acidic organic sulphur compounds principally as disulfides by oxidizing with sodium or calcium hypochlorite. The principal reaction may be expressed as follows:

$$\begin{matrix} RSH \\ + \\ RSH \end{matrix} \quad \begin{matrix} \diagup Na \\ 0 \\ \diagdown Cl \end{matrix} \rightarrow \quad \begin{matrix} RS \\ | \\ RS \end{matrix} \quad + \; NaCl + H_2O \quad (3)$$

The disulphides are soluble in gasoline and are retained in it, but since they are negative to the "doctor" test the gasoline now tests "sweet." Some authorities consider hypochlorous acid the principal oxidizing agent. Since its formula is very similar to sodium hypochlorite, there is no change in the formation of disulphides. It should be remembered that hypochlorite solutions in the treating plant are prepared with an excess of caustic soda or lime in order to make the finished solution more stable than a solution of true hypochlorous acid. Hence, for all practical purposes the above reaction seems to be the principal one and whatever hypochlorous acid does react with the mercaptans it may be considered as an intermediate reaction. The investigation and its results described

[1]Birch, *The Oil and Gas Journal*, 1929, Vol. 29, May 23rd, p. 190, and May 30th, p. 38.

[2]By associates of Birch and by the writer, who had, independently and prior to the publication of Birch's article, discovered this fact.

herein are primarily concerned with the solubility of mercaptans in caustic soda solutions.

Description of Treating Plant Operation. The treating plant at which the observations were made consisted of six vertical towers, 4 ft. by 20 ft., equipped with special mixing devices. The first four towers were filled about three-fourths full of 7-deg. Bé. caustic soda solution and the last two towers held the sodium hypochlorite solution. As shown in the accompanying schematic diagram, Fig. 1, the untreated stabilized gasoline entered under pressure the bottom of caustic tower No. 1 through a special mixing device, which insured intimate contact between the gasoline and the caustic solution and also kept the caustic solution in the tower thoroughly mixed. After passing up through the tower, the gasoline flowed over to caustic tower No. 2 and repeated its upward passage through the mixing device and caustic solution before overflowing into caustic tower No. 3 and then on over to caustic tower No. 4. After leaving tower No. 4, the caustic-washed gasoline passed in a similar manner through "hypo" towers Nos. 1 and 2, leaving them and passing on to storage as "doctor sweet" gasoline.

Operation of plant at that time: Fresh "hypo" (sodium hypochlorite) solution of suitable strength and amount was charged into hypo tower No. 1 every half hour by means of a blown-in tank. Best results were obtained when the available chlorine content of the solution in this tower was sufficient to make the gasoline leaving at the end of the half-hour period "doctor sweet." The accumulation of spent hypo solution was drained off to the sewer at intervals as determined by experience and then partly filled with fresh water, but between times the excess accumulation of hypo solution in No. 1 was carried over to hypo tower No. 2. The latter served as a pick-up tower to sweeten any "sour" gasoline that should happen to leave No. 1 and also served to carry the treating "load" while No. 1 was being drained. The accumulation of hypo solution in No. 2 was drained to the sewer frequently. The principal point in this operation was to keep just enough available chlorine in No. 1 hypo tower to sweeten all the gasoline passing through during the half-hour interval between charges of fresh hypo solution.

The cycle for changing caustic solutions in the four caustic towers was as follows: Every 24 hrs. the solution in caustic tower No. 1 was drained to the sewer. The solution in caustic tower No. 2 was pumped over into No. 1, then the solution in caustic tower No. 3 over into No. 2 and the solution in No. 4 over into No. 3. Caustic tower No. 4 was then charged with fresh 7-deg. Bé. caustic soda solution. Experience showed that for the volume of gasoline being treated, the amount of caustic soda in solution in the four towers gave the most practical results, as measured by minimum consumption of chlorine, for a 24-hr. cycle in this plant and that it rarely paid to vary from the 24-hr. period between changes.

Chemical tests repeatedly demonstrated that the gasoline leaving caustic tower No. 1 was always free of hydrogen sulphide. This left the fresher caustic solutions in towers Nos. 2, 3, and 4 to react as much as possible with the mercaptans in the gasoline.

Since this plant was in a "sour" gas field, the natural gasoline extracted from the gas naturally had a very high hydrogen sulphide and mercaptan content. Some idea of the relative difficulty in treating this gasoline "doctor sweet" as compared with other natural gasolines may be gained from the following table:

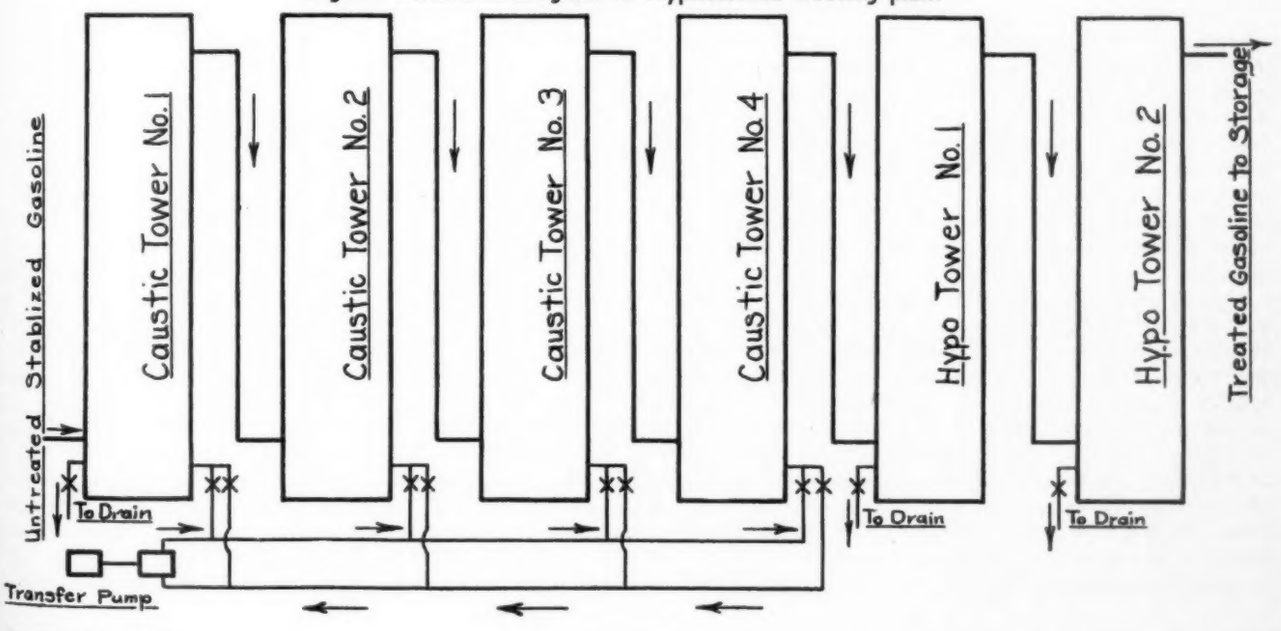
	Hydrogen Sulphide		Sulphur Present As Mercaptans	
	Lb./M Gal.	Gms./Liter	Lb./M Gal.	Gms./Liter
This Plant	1.70	0.204	4.30	0.515
Plant A	0.00	0.000	1.37	0.164
Plant B	0.022	0.0027	0.025	0.003

In passing it is interesting to note that the treating plant began using 37 per cent less chlorine after changing over from 20-deg. Bé. caustic solutions to 7-deg. Bé. solutions. The savings in chemicals at that time amounted to $20.00 per day.

Effect of Temperature on Hypochlorite Treating. The treating plant had been under continued close observation after changing to dilute caustic solutions and minor changes in its operation had been made from time to time in trying to effect further economies. Thus, the record-gathering system was in good working order to reveal a substantial sustained decrease in the consumption of chlorine from about 8.0 lb. per M gal. of gasoline to less than 6.0 lb. per M gal. during an unprecedentedly long spell of very cold weather. It was significant that such a change should occur at the time the solutions in the towers were the coldest. The record-gathering system was augmented to procure the additional data needed for studying this phenomenon.

It is significant to note that for January, the month of cold weather, the average consumption of chlorine was 5.5 lb. per M gal. of gasoline and for the preceding month of December it was 8.05 lb. per M gal. This made a saving in chlorine of 31.7 per cent without any change in the method of operating the treating plant.

Fig. 1—Schematic diagram of Hypochlorite treating plant



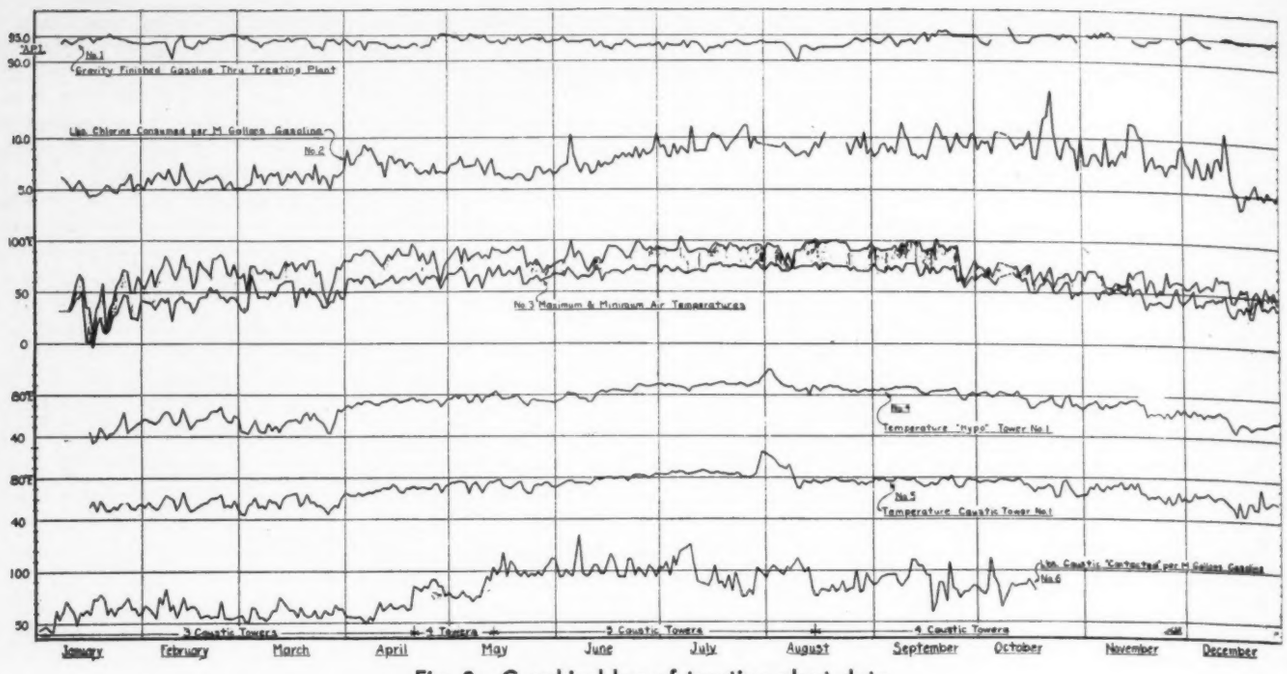


Fig. 2—Graphical log of treating plant data

A very large amount of data was collected. These data have been plotted graphically in order to facilitate study. In Fig. 2 it will be noticed that the gravity of the finished gasoline (curve No. 1) in general stayed within a narrow range of fluctuations except for several periods of a few days each. During July and August the gravity was on the average one deg. A.P.I. lower. For all practical purposes the finished gasoline remained nearly the same throughout the year.

The daily maximum and minimum air temperatures are shown in curve No. 3. Temperatures of the solutions in hypo tower No. 1 and caustic tower No. 1, taken at the same time every day, are shown in curves Nos. 4 and 5 respectively. Except for the large humps in the latter two curves at the end of July caused by a special experiment, all three temperature curves are naturally interdependent and by themselves require no further comment because they are a record of the existing temperatures at that time and at those places.

These curves assume a place of importance, however, when studied in conjunction with the chlorine consumption shown in curve No. 2. Before this record of temperatures was started, there had been a period of nearly two weeks in which air temperatures throughout the day ranged between 0 and 10 deg. fahrenheit. Solutions in the treating plant towers were naturally thoroughly cooled below the normal temperatures. The effect of this soon appeared in a decreased consumption of chlorine. Thus, when this detailed record was started toward the end of the severe cold spell, the curve for chlorine consumed was downward and the first day shown here is reported at 6.3 lb. per M gal. of gasoline. The consumption declined each day until it had reached 4.9 lb. per M gal. of gasoline.

During that time atmospheric temperature had been reported below 32 deg. fahr. but air temperatures began rising the day of the lowest chlorine consumption and continued upward to a maximum of 68 deg. fahr. before taking a downward plunge that ended with temperatures of 0 deg. fahr. several nights in succession before another upward trend began. It will be observed—and this is the particularly significant point—that the chlorine consumption increased during the first rise in temperature and then decreased as the air temperatures plunged down to zero again. The chlorine consumption decreased to a record of 4.2 to 4.5 lb. per M gal. of gasoline during those cold days.

The record of the solution temperatures in caustic tower No. 1 and hypo tower No. 1 had been started by this time. Thus it will be observed that every time the curve of chlorine consumption touches 5.0 lb. or lower the temperature of the solution in caustic tower No. 1 is very close to 50 deg. fahr. or lower. If the reader will follow this point of comparison for these two curves throughout the year, even into December, he will be surprised at the remarkable coincidence.

It should be stated at this point that the temperatures taken daily for this record were chosen more from the standpoint of convenience, and the regularity of the time the temperatures were taken each day served to furnish a record of their trend at the various points rather than the actual maximum or minimum readings. It became apparent that trends were more important and sufficient for the purposes of this study because the air temperatures could not ordinarily affect sudden changes in the temperatures of the treating solutions in the towers.

Likewise, during the first three months of the year when the temperature of the solution in caustic tower No. 1 stayed below 60 deg. fahr. most of the time, the peaks of maximum chlorine consumption coincide fairly closely with the peaks of temperature. This is additional confirmation of the effect of temperature on the chlorine consumption.

Above 60 deg. fahr. for the solution in caustic tower No. 1, the agreement is not so good. It is significant though that as the temperature of the solution rose during May, June and July the consumption of chlorine followed a rising trend.

Curve No. 6 shows the computed weight of caustic in the solutions in the caustic towers. The important point to notice is that only three caustic towers were in use until toward the end of April. Thus, when the temperature of the solution in caustic tower No. 1 had definitely crossed into the warmer regions above 60 deg. fahr. the consumption of chlorine reflected a definite increase. Then the addition of the fourth caustic tower made a definite decrease in the chlorine consumption of approximately 1.0 lb. per M gal. of gasoline even though the general temperature level of caustic tower No. 1 remained the same. With the addition of a fifth tower of caustic solution, the chlorine consumption was again definitely decreased approximately another 1.0 lb. per M gal. of gasoline and remained close to that general level for several weeks until the trend of the temperature in caustic tower No. 1

began to rise definitely into the region above 80 deg. fahrenheit. During June and July the increase in chlorine consumption was in general a reflection of the increase in the temperature of the caustic solution.

The bulge in the curves at the end of July was caused by a special experiment to be described later. For the remainder of the year the curves are not so comparable to the first part of the year because gasoline from a new plant had increased the treating plant load to about twice the daily volume of that earlier in the year. It is significant though that after operating troubles in the new gasoline plant had been smoothed out in October and the throughput of gasoline became steadier there was a definite decrease in the chlorine consumption—even though only four towers of caustic solution were in regular use. The trend of this decreasing consumption followed the trend of decreasing temperature of the solutions in caustic tower No. 1. When the temperatures fell below 60 deg. fahr., chlorine consumption declined again to the low region of 5.0 lb. per M gal. of gasoline treated.

Suggested Explanation of Phenomenon. It has been definitely proven that the consumption of chlorine was greater in the summer months when the temperatures of the treating solutions were higher than in the winter months when the temperatures of these solutions were lower. When the temperatures in No. 1 tower were around 50 to 60 deg. fahr. or lower, the chlorine consumption averaged close to 5.0 lb. per M gal. of gasoline. Thus, a change of 20 to 30 deg. fahr. in the temperatures of the treating solutions made a change of approximately 4.0 lb. in the consumption of chlorine per M gal. of gasoline treated, a decrease of 44.5 per cent.

It has been clearly demonstrated by Birch and others[2] that with the use of dilute caustic soda solutions, 7 deg. Bé. (5 per cent) being the most practical, the solubility of mercaptans in dilute aqueous caustic solutions has an important part in the hypochlorite process for making gasoline "doctor sweet." As explained in the second step of the chemistry of the process, any change in the water content of the system water, sodium mercaptide, caustic soda and mercaptan shifted the equilibrium point of the reversible reaction of this system and in turn affected the value of the constant partition coefficient for the solubility of mercaptan in oil (gasoline) and the solubility of mercaptan in water that had to be corrected (brought back to its constant value) by a shifting of mercaptans from oil to water or vice versa as required.

It is the writer's belief that temperature plays a very important part in the mercaptan-solubility of aqueous caustic soda solutions. Fundamentally, a larger quantity of a given chemical can be dissolved in hot water than in the same volume of cold water. One outstanding exception to this general law of chemistry is hydrogen sulphide. Its solubility in water decreases as the temperature increases finally reaching a point where it can be completely boiled off. Mercaptans as a class have characteristics very similar to hydrogen sulphide. Hence, it is reasonable to infer that the solubility of mercaptans in water decreases with increases in temperature.

If this is true, then an increase in the temperature of the dilute caustic soda solution releases part of the dissolved mercaptan causing it to shift from the water to the gasoline (oil). Thus, at the higher temperatures, the mercaptan-content of the caustic-washed gasoline would be greater and there would be more sodium hypochlorite used in treating the additional amount of mercaptan. The evidence presented by these observations seems to verify this conclusion.

If this is true, then the constant partition coefficient "k" has a definite value for each temperature. In view of the knowledge available for the values of "k" in other systems, it hardly seems likely that the "k" for this system would have the same value at all temperatures.

One argument has been advanced to refute the foregoing explanation. Briefly it is this: Since more vapors are obtained from the gun-barrels during the summer months than during the winter because the summer temperatures warm the crude oil more, it is assumed that the vapors carry a greater percentage of hydrogen sulphide and mercaptans. Contrawise, with the lower temperatures during winter there is less vaporization and less hydrogen sulphide and fewer mercaptans released. This appears to be quite reasonable except for one fact: At this plant more than 95 per cent of the natural gas came direct from high-pressure producing oil wells. The ratio of expansion of the gas from well pressure to gathering line pressure was so large that a very appreciable cooling effect was exerted and the temperature of the pipe in the gathering system was very cool—between 40 and 55 deg. fahrenheit. The temperature of this system remained comparatively uniform throughout the year because the pipe was buried in the ground and the temperatures of the oil and gas at the casinghead were sub-surface and not atmospheric and not very likely to be affected much by changes in surface temperatures.

Special Temperature Rise Test. Therefore, to test out the foregoing theories, a special high-temperature test was made the latter part of July. The temperature of the solutions in the treating plant was increased by cutting off the final cooler on the stabilizer and letting the gasoline enter the treating plant uncooled. If temperature does not have any effect on the mercaptan-solubility of the caustic soda solutions, then there should be no change in the chlorine consumption, thereby proving the argument against the temperature effect on the mercaptan solubility.

What actually happened was this: The temperature of the incoming gasoline was approximately 25 deg. fahr. higher. In due time, much quicker than anticipated, the treating plant solutions reached a temperature equilibrium approximately 20 deg. fahr. higher. Shortly thereafter, the half-hour charges of fresh hypochlorite solution had to be increased. The end of the first day's run of this higher temperature did not show much higher consumption, but for the second day's run the consumption had jumped to 12.5 lb. of chlorine per M gal. of gasoline—an increase of approximately 31 per cent. On the third day the consumption had increased to 14.7 lb. per M. gal. of gasoline—an increase of approximately 55 per cent over ordinary conditions, and on the fourth day the consumption had climbed to 16.0 lb. of chlorine per M gal. of gasoline —an increase of approximately 68 per cent.

The experiment was stopped at this point by putting the gasoline through the final cooler. As the temperatures of the treating solutions decreased, the consumption of chlorine decreased finally reaching the amount just preceding this test when the treating plant temperatures were back to normal. It was obvious that if the test had continued for several days more, the full effect of the higher temperatures would have been shown by the chlorine consumption reaching a more uniform value at some value slightly higher than that of 16.0 lb. for the fourth day—perhaps not over 18 pounds.

However, the four-day test was sufficient to prove conclusively that temperature does have a strong influence on the solubility of mercaptans in dilute aqueous solutions. All other conditions were practically *unchanged* and there had been no increase in gun-barrel vapors and temperatures. It is entirely reasonable to assume there is a slight increase in the hydrogen sulphide and mercaptan content of the vapors in the summer months but not to the extent that approximately four more pounds of chlorine are required to treat the additional mercaptans. In order to verify this theory further, the chlorine consumption data were re-plotted on a lb.-temperature basis instead of a lb.-day basis. This plot is shown in Fig. 3 with the temperature scale on the vertical and the lb.-consumed scale on the horizontal. These data were plotted for 3-tower, 4-tower and 5-tower contact with caustic. It is significant that for the 3-tower contact, the mass of points show distinctly an increase in consumption of chlorine as the temperature increased. The shorter curve is the best approximation that could be drawn from these data to show the trend.

Likewise, the mass of points for the 5-tower contact shows a distinct increase in chlorine consumption as the temperature of the solutions increased. The points from the special four-day test definitely fixed the upper end of the curve, which was drawn through the data available. The lower end was turned more than was warranted merely to average in the effect of the 3-tower data. It is quite probable that the 5-tower curve by itself would cross the 60-deg. fahr. line at a consumption of between 4.5 lb. and 5.0 lb. of chlorine per M gal. of gasoline. Although the opportunity did not present itself to test this out in the plant for the same conditions as the 3-tower data, it appears entirely reasonable to expect such low chlorine consumption at temperatures higher than for the same consumption with the 3-tower contact.

Thus, the re-plotting of the data and the resultant curves show definitely that *temperature does have a strong effect on the mercaptan-solubility of dilute aqueous caustic soda solutions.*

Effect of Time on Hypochlorite Treating. Time is also an important factor in obtaining the greatest solubility of mercaptans in the aqueous caustic solutions. Obviously from a practical standpoint other factors such as changes in the volume of gasoline treated, expense for labor, plant design, etc., do not permit the most efficient utilization of the caustic solutions. Economically though, experience will soon determine the most practicable way to operate the treating plant.

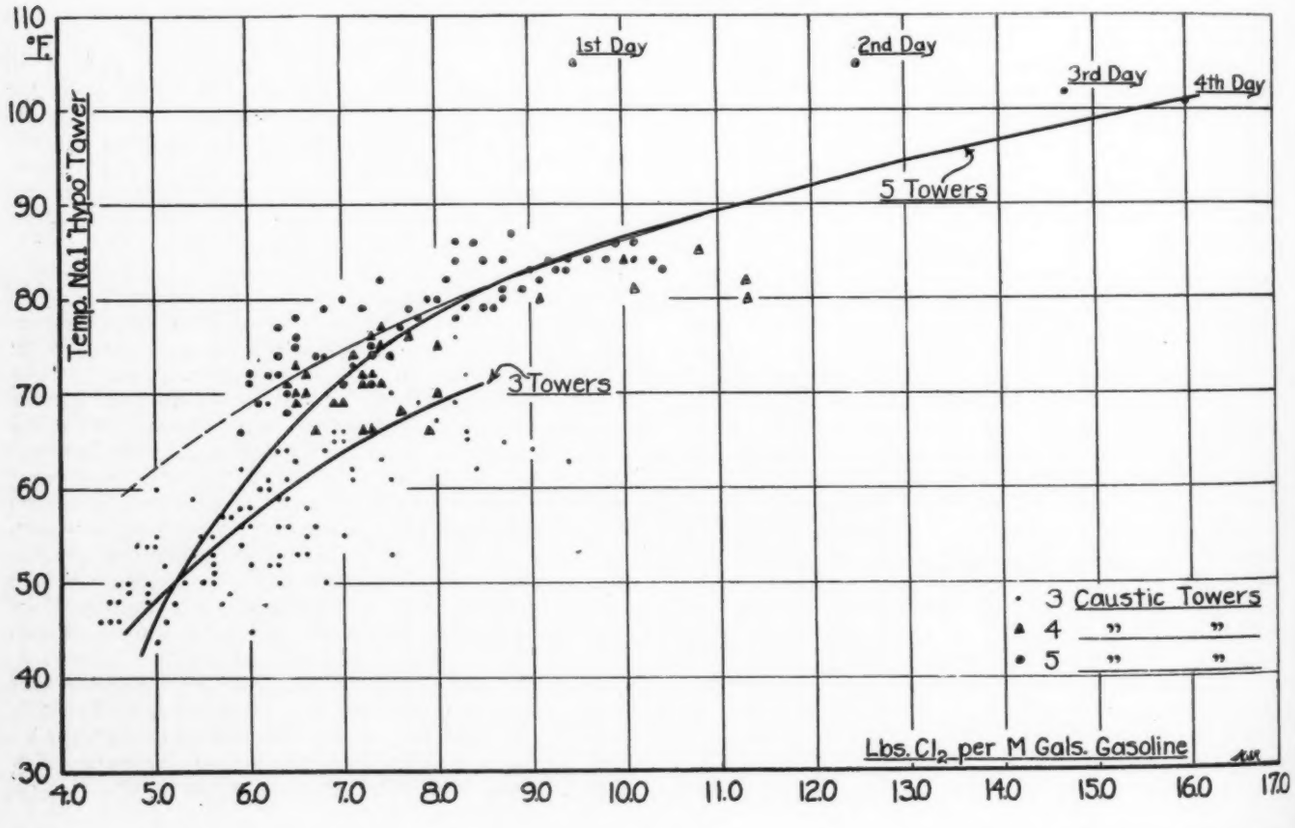
Thus, in all the data presented herein, the effect of time on the mercaptan-solubility of aqueous caustic solutions has always been implied if not specifically mentioned. Theoretically, exact time studies might have been made provided such variables as the volume of gasoline treated, solution temperatures, and the like could have been held constant for days at a time. Gasoline plant operating conditions do not permit such close operation. Hence, the time element in the operation of this plant was worked out by experience to balance the effects of as many variables as possible and give practically the most economical operation.

One obvious improvement suggested by theoretical considerations of the time element is a continuous counter-current flow of dilute aqueous caustic solution through a sufficient number of towers and at such a rate as to contact a given flow of gasoline and remove the maximum amount of mercaptans. This arrangement would insure when suitably adjusted the removal from the system of the caustic solution as soon as it had become saturated with mercaptans. Thus, it might be found practical to use a more dilute solution than 7 deg. Bé. and also to remove more of the mercaptan than in the plant described in this paper.

Mechanical and economical difficulties appear although they might be overcome in a suitably designed plant. The number of chemical proportioning pumps and the number of towers required would have to be varied for changes in the volume of gasoline handled. This would imply a large investment in equipment needed only part of the time for efficient chemical handling of peak loads. Next, changes in adjustment of flow of caustic solution with changes in flow of gasoline might become burdensome when the flow of gasoline from the gasoline plant fluctuated widely as happens at times. Of course, such improvements would not be justified if they did not effect substantial savings in the operation of the plant.

Practical Considerations of Temperature Effect. It is evident that where the volume of chlorine used daily in hypochlorite treating is large substantial savings in the consumption of chemicals could be made in a plant designed to maintain the temperatures of the treating solutions throughout the year near the optimum of 50 deg. fahr. as indicated by the data presented above. Since most gasoline plants now have high-pressure stabilizers, it should not be very expensive to install a cooling system utilizing the reflux liquids from the stabilizer as the refrigerant. Herein is the germ of an idea that might be applied quite simply in any one of several ways to fit local conditions. Experiments and computations can be made to determine whether or not the savings would justify applying this idea to regular treating plant operation.

Fig. 3—Temperature-chlorine consumption curves



Well with wooden piling on which pumping machinery will be erected. This well is in a swamp in the East Texas field

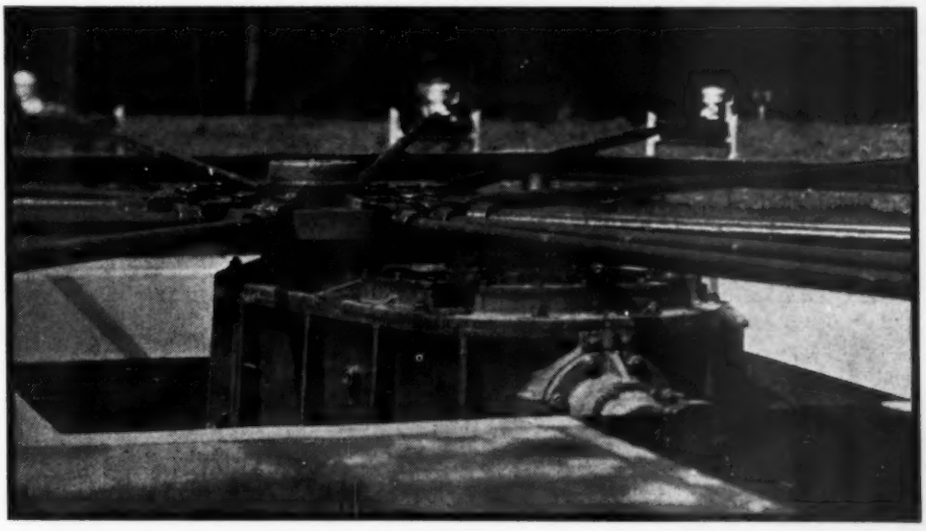
By K. C. SCLATER

Changing Reservoir Pressures Influencing East Texas Producing Conditions

WITH production virtually under control and crude prices rapidly on the increase to levels more in keeping with actual production costs, a real incentive has been provided operators in the East Texas field to turn their attention to production problems and to give some sound thought to the immediate future trend of flowing and pumping conditions in that field; for there is every indication that by adherence to the production provisions of the NRA code, which went into effect September 8, East Texas crude will bring a stable price in the market of a dollar or more a barrel.

As the economic situation improves, the higher crude prices obtaining will put a premium on efficient well operation and operators will strive to produce the maximum allowable from every one of their wells daily. An operator in the East Texas field who fails to produce his full quota each day will have no opportunity to make it up at a later date. One of the disturbing factors in prorating the field in the past has been the granting of back allowables. It now seems almost certain that the Railroad Commission will, for the present at least, discontinue this practice. Present proration regulations for the field assume that the well, and not the lease, is the unit from which no more than the allocated quantity of oil may be taken daily; consequently, if a well fails to make its daily production, the amount by which it falls short may not be taken from another well. The main purpose of this regulation is to minimize the harmful effects of unequal drainage between offsetting wells. Strict compliance with these regulations may therefore be required in the future, in view of which, and in the face of higher crude prices, the matter of maintaining each well in condition so that it can produce its quota of oil daily becomes of paramount importance. A well off for a day, or unable to produce its daily allowable will, with oil at a dollar or more a bbl., result in a loss of revenue serious enough to have a salutary effect that will jolt the operator into taking immediate action to correct the trouble. The adoption of effective measures to enforce these regulations to the letter should redound to the benefit of every operator in the field and will accentuate the importance of keeping wells on production, free from interruption or shut-downs.

Bottom-hole pressure measurements made in August showed a few pounds increase in the average bottom-hole pressure over that of July. A sudden drop in withdrawals from the pool in July when the running of "hot" oil was halted caused this backing-up of bottom-hole pressure at the wells. About the middle of July the average bottom-hole pressure, according to tests made by engineers of the Railroad Commission was 1202 lb. (see chart); by August 5, the average bottom-hole pressure had built up to 1240 lb. and on



This Lufkin geared power in the northern part of the field will pump 17 wells

Pulling tubing on well in Gladewater area. Note how mule-head of Parkersburg pumping unit is swung out of the way during this operation

August 25, had declined again to 1222 lb., an average bottom-hole pressure reached on two previous occasions, June 15 to June 30. Evidently, equalization of the pressure in the reservoir was still in progress on August 25, when the last bottom-hole pressure measurements were taken. On September 8, when the NRA code went into effect, the daily allowable production for the field was reduced from 620,000 to 465,000 bbl., as a result of which it is estimated there will be another increase in the average bottom-hole pressure, which will be followed by a decline until equalization of reservoir pressure at the new lower rate of withdrawal is reached. Judging from the trend of the bottom-hole pressure since July with respect to the production from the pool, equalization of the reservoir pressure may not be reached for a period of two months, by which time a fairly regular rate of decline in bottom-hole pressure should be discernible.

In the accompanying chart, plotted from data obtained and compiled by the engineering department of the Railroad Commission, the relation between average bottom-hole pressure and production can be observed, as well as a comparison of the known quantity of oil produced with that of the allowable. The bottom-hole or depth pressures are the weekly average of tests made on wells in eight east-west cross sections spaced at regular intervals the entire length of the field from north to south, there being four wells in each section, or 32 wells in all. As production represented by the curve is the total quantity of oil run from the field and may include oil drawn from field storage it may differ slightly from the actual volume withdrawal from the wells. The curves show quite clearly how excessive daily withdrawal influences the bottom-hole pressure, and the adjustment of reservoir pressure that takes place when a change in the rate of withdrawal is imposed on the field.

From August 7 to August 25, the increasing daily rate of withdrawal is reflected to some extent in the rate of decline of bottom-hole pressure; during this period the rate of decline was about 1.4 lb. per million bbl. of oil produced—a rate of decline greater than had been predicted by many after the building up of the bottom-hole pressure during the latter part of July had been observed.

Much confusion has arisen over the building up of bottom-hole pressures and the part that hydrostatic pressure plays in maintaining the reservoir pressure in the East Texas field. At an average reservoir pressure of 1225 lb. and withdrawal at the rate of 600,000 bbl. daily, the total quantity of water produced has been relatively small; available field evidence indicates that even a withdrawal at the rate of 465,000 bbl. daily will result in a probable average drop in reservoir pressure of about one lb. per million bbl. of oil produced.

From July 21 to August 19 there was a reported increase in the number of wells showing water from 380 to 450, or an average of more than two wells a day. The amount the total volume of water has increased is not, however, reflected in the increase in the number of wells; the actual percentage increase in water is very much less. Nevertheless, the fact that water is showing up in an increasingly greater number of wells suggests that those areas of the field where water is encroaching should be carefully watched and the effect on the flow of the wells investigated.

Early in July, when daily withdrawals from the field were excessive, many wells reached the critical stage of their flowing life and had to be given occasional aid by swabbing or agitating. This critical point is known in the most of those wells and can be anticipated by observing the bottom-hole pressure; for the bottom-hole pressure in the well, and not the rate of withdrawal from the field, is the factor by which this critical point can be determined. It is well to bear these facts in mind when estimating a well's flowing life.

Observations in the field disclose that the building up of bottom-hole pressures during the latter part of the month of July has exerted some influence on the flowing and pumping conditions throughout the field. The number of wells requiring frequent swabbing and agitation has decreased due to the beneficial effects resulting from the increase in bottom-hole pressure; and these wells that were nearing the pumping stage have had their flowing life prolonged for a month or two. This has made operators delay equipping a number of their wells; they prefer to wait until the results of the NRA code curtailment regulations on reservoir pressures in the East Texas field are more evident. In the meantime, many operators are taking the precaution of equipping some of their wells for gas-lift. Early this month the total number of applications for permits for the use of gas-lift in the field had reached about 700. When these permits are granted operators are required to provide the Railroad Commission with full information regarding the well, including: the name of the system and any flowing devices to be used; input and outlet pressures, kick-off and working; size and depth of tubing; bottom perforation; make and type of packer; date of installation, and a general description and line sketch of the hook-up at the well.

A variety of gas-lift devices are in use in the field; chief among these are the kick-off valves, of which there are several makes in use, including: Bryan, Williamson, P. & T., Greenlee-Taylor, Simmons, and Southern States Company valves. There are also several pumps in use that operate on gas-lift principles, these include: the Hughes Lift, the Haywood Siphon Lift, a pump manufactured by Clark Bros. Company that is of the displacement type, and another manufactured by the Halliburton Oil Well Cementing Company.

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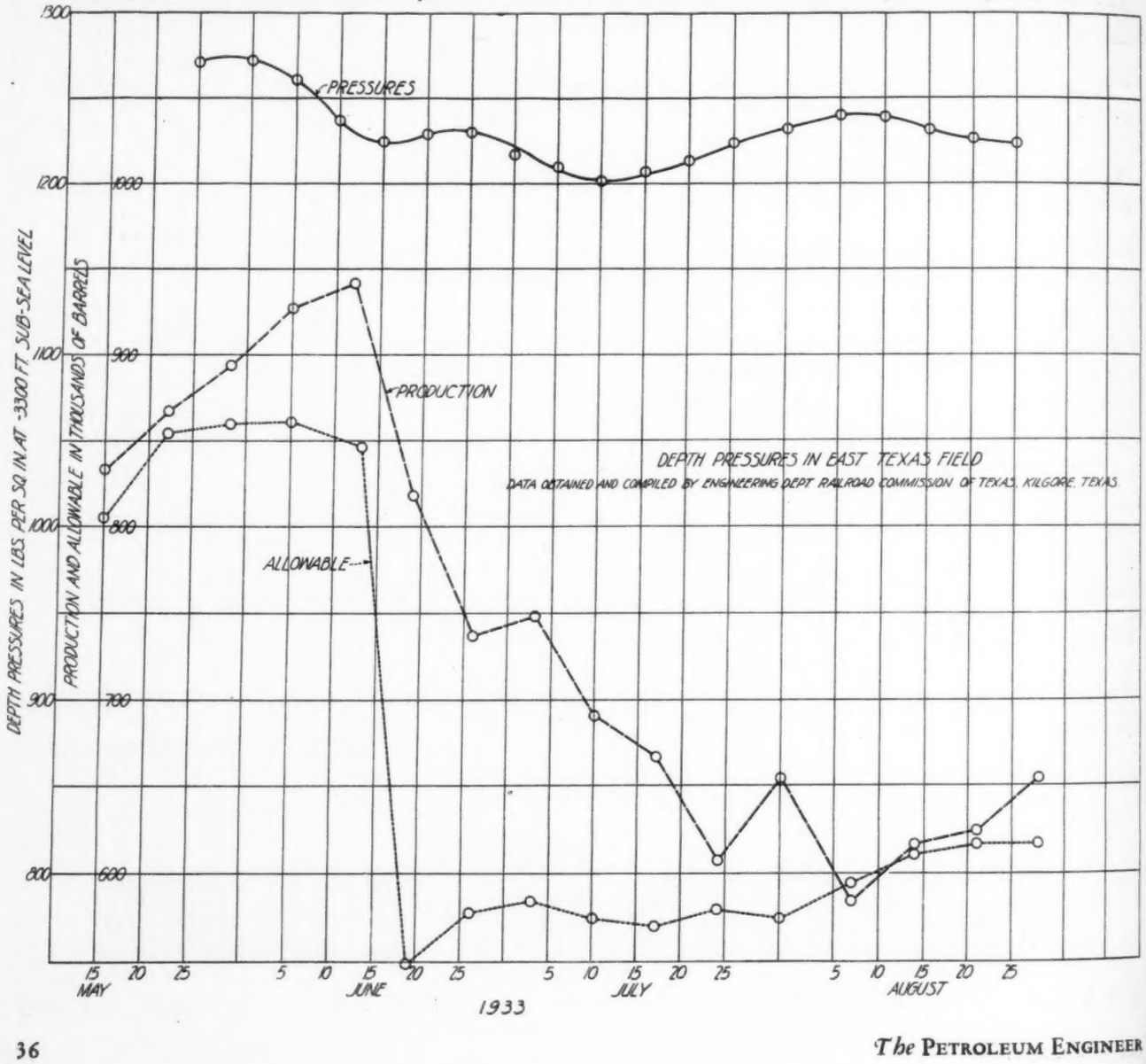
Time-cycle regulators for the automatic operation of flowing wells intermittently have also been in use in the field for some time. The kick-off valves are being installed in wells the natural flow of which is weakening and in wells that cause difficulty in starting to flow. By means of the kick-off valves and the use of air or residue gas the flowing life of wells can be prolonged and high kick-off pressures avoided. One major company now has 16 wells in the Kilgore-Joiner area on the artificial gas-lift; these are equipped with kick-off valves, by means of which the wells are kicked-off daily and flowed with residue gas as make-up with an average input gas-oil ratio of 300 cu. ft. per barrel. The kick-off pressures required vary in the different wells from 125 to 300 lb., the amount depending on the character and condition of the well and the method of operation. Encouraging results are being obtained in controlling fluid levels in these wells by back pressure at the casinghead, an operation that seems to be vital to the success that is obtained in producing these wells efficiently, and with minimum kick-off pressures and low input gas-oil ratios.

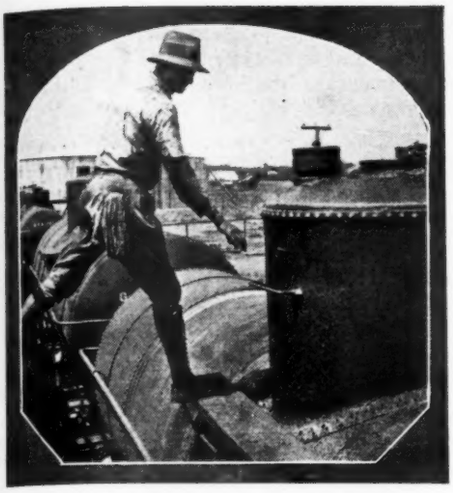
Although the critical bottom-hole pressure at which the average well in the field is believed to be between 950 and 1000 lb., there are several examples of wells having a natural vigorous flow at much lower pressures. One such example is that of a well in the East Joiner area. Although this well has a bottom-hole pressure of only 630 lb., it flows naturally without difficulty and is started up daily without artificial stimulation of any kind. It produces into a separator under 7-lb. pressure with a surface oil temperature of 96 deg. fahr., and a gas-oil ratio, carefully measured and corrected to standard conditions of pressure and temperature, of 425 cu. ft. per barrel. The well has a low fluid level when shut in; tests with a pressure bomb show a gas-column pressure gradient to a depth below 3000 feet depth. The space between the casing and tubing is effectively packed off with a packer on the tubing about four joints off bottom.

Being in an area where the rate of production was excessive, what probably happened in this well was: wells in the vicinity were produced at such a high rate that the reservoir pressure was reduced far below that at which the gas starts to come out of solution, the net result of which would be a dissemination of free gas in the sand throughout the area. When the pressure built up it would create a favorable condition for natural well flow, for small gas bubbles would then be distributed in the oil in the sand, thus keeping the well lively and responsive to natural flow. The fact, however, that this well flows with a low bottom-hole pressure does not justify the assumption that other wells in the field will do likewise. Local sand conditions and the proximity of water will have to be taken into consideration.

Curves show trend of bottom-hole pressure in East Texas and how it is affected by rate of production



Petroleum Industry Makes Progress in Accident Prevention



Stepping across from loading rack to tank car is a very dangerous practice. Workmen must be educated to use the walkway

By C. L. HIGHTOWER

Safety Director
Texas Pacific
Coal & Oil
Company

Proper spacing of men on ditching work will eliminate the possibility of injuries from being struck by pick or shovel

THE petroleum industry is pointing the way in accident prevention work. In 1927, oil companies in the United States who were reporting to the National Safety Council experienced an accident frequency 18 per cent greater than the average of all industry, while in 1931 this experience had so improved that the frequency of the petroleum industry was 6½ per cent lower than all industry. All industry figures are not available for 1932 but the petroleum industry reported a 13 per cent improvement over 1931, making a 60 per cent reduction in the frequency of disabling injuries over the past six-year period.

The progress made by the industry in controlling the accident situation has not only resulted in the saving of human life and the reduction of disabling injuries, but has effected an economic saving of millions of dollars to employees through the lessening of absenteeism.

Lowered insurance costs, increased efficiency in operation, elimination of waste and improved morale have been the direct benefits industry has received from its accident prevention program. In times of economic distress, these items are of increasing importance, and oil companies have, as a rule, intensified their accident prevention activities rather than follow a policy of drastic retrenchment in this department. This is conclusive proof that the work has established itself of definite economic value both to employer and employee, and that accident prevention is accepted as an integral part of the operating program.

As between departments of the industry, pipe line companies have shown the greatest per cent reduction in disabling injuries, having lowered their frequency from 64.22 in 1926 to 17.31 in 1932. In spite of this improvement, however, pipe line operations still reflect a higher accident frequency for 1932 than the average of all departments, which was 12.28. Marketing and refining operations alone show a frequency rate under the average established by all other departments for last year. The rate for marketing was 8.80, while that of refining was 9.01. Development and producing operations reflect the highest frequency for 1932, this department having established a rate of 25.32. Natural gasoline was third highest with a frequency of 15.38.

Accident prevention is considered by the petroleum industry as a science; namely, the science of correct operation. Carelessness has been discarded as an alibi for accident, and the "Be Careful" poster and other abstract messages are being replaced by definite and instructive information.

Three major activities form the basis of the accident prevention program in the progresive company. They are: engineering revision in lay-out and construction, proper maintenance of equipment through scheduled inspections, and training of workers concerning safe job practices.

Accidents of the past have pointed out the need of engineering revision pertaining to lay-out and installation of equipment in all departments of the industry. Pump houses at refineries and natural gasoline plants are now of open-type construction as compared to the old type enclosed building, which created a fire and explosion hazard by reason of inadequate ventilation. Vapor-proof electrical equipment in the producing, marketing, as well as in refining and natural gasoline operations, has eliminated sources of ignition in possible gas or vapor areas.

The recently developed method of "washing-in" oil wells is not only a measure of economy, but lessens accident hazards as well. "Hook-ups" for controlling wild or burning wells have been developed so that men can perform what is usually considered extremely hazardous work without direct exposure and in comparative safety.

The installation of vapor recovery systems at storage tanks and the use of flame arrestor equipment where residue gas from tank batteries is burned, are engineering developments that have added to the safety of the public as well as oil company workers.

Methods of detecting toxicity and explosibility ranges of vapors in storage tanks, tank cars, and pressure vessels by means of accurate and simple measuring equipment may be

listed as noteworthy engineering advancements that have contributed to the safety of petroleum workers.

Constantly changing methods and the development of new equipment lend particular importance to the question of engineering as applied to accident prevention; and the progressive company undertakes no new construction or change in operating processes without first considering the effect of such change from the standpoint of the worker's safety.

The inspection program of today goes further than the mere detection of poor housekeeping conditions. It should be, and usually is, planned so as to maintain definite schedules of inspection to insure proper operation of equipment. This is particularly true with pressure equipment where a failure is likely to result in an accident of catastrophic proportions.

The inspection of shell stills, pipe stills, vapor towers and high-pressure cracking units is usually left to the mechanical and operating departments, but records of such inspections that show material thicknesses, effects of corrosion, etc., are usually furnished the accident prevention department. Reports on repairs and replacements are also usually followed up by this department.

Where the inspection program is outlined so as to develop information regarding mechanical condition of equipment as well as practices followed in its operation, the purpose of economy as well as accident prevention is served, since changes may be worked out or processes developed that eliminates replacement or additional equipment by the study of the information thus developed.

The thoroughness and sincerity with which the inspection program is carried out will to a great extent influence the worker's interest in and support for accident prevention. If the management indicates a lack of interest by lax or incomplete inspections, it can not expect that the worker will be too enthusiastic in the work of correcting unsafe conditions and practices.

However, only a small per cent of accidents are chargeable to mechanical failures or improper lay-out in design and construction injuries resulting from these causes are usually serious; for this reason engineering and inspection should be given paramount consideration in planning the accident prevention program.

The training of workers in safe job practices is a task that falls on the shoulders of the supervisor. It is the plant superintendent or foreman who has the job of selecting the new man, instructing him about his job and assigning him to work. Since we recognize the need of making accident prevention a definite part of operation and since the supervisor is the individual in the organization having direct contact with the worker, it logically follows that he is the man to undertake the task of safety training.

Comparison of Accident Frequency and Severity by Departments for the Years 1927 to 1932, Inclusive

Year	No. of Workers Reported	No. of Workers to Each Fatality	No. of Workers to Each Lost-Time Injury	Accident Frequency	Accident Severity
ALL DEPARTMENTS					
1932	226,304	1,810	32	12.28	1.91
1931	227,360	1,749	28	14.14	2.06
1930	230,471	1,647	22	18.05	2.37
1929	226,280	1,498	15	26.78	2.49
1928	99,477	1,292	15	27.33	2.69
1927	88,572	1,476	11	31.15	2.65
REFINING					
1932	58,431	1,359	44	9.01	2.30
1931	70,358	1,466	35	11.51	2.14
1930	75,815	1,204	28	14.06	2.93
1929	79,896	1,309	19	21.06	2.62
1928	27,528	1,147	24	16.75	2.57
1927	34,761	1,511	24	16.49	2.30
MARKETING					
1932	92,471	3,425	45	8.80	.96
1931	76,191	5,442	45	8.74	.69
1930	68,839	3,824	38	10.41	.99
1929	60,183	5,015	32	12.42	.74
1928	13,996	2,799	22	18.06	1.35
1927	15,909	.....	26	15.44	.58
PRODUCTION					
1932	36,772	1,021	16	25.32	3.73
1931	40,678	1,017	15	25.97	4.02
1930	47,741	1,256	13	31.79	3.49
1929	47,100	812	8	47.68	4.59
1928	27,023	1,175	9	44.21	3.35
1927	14,474	1,033	6	59.59	3.62
NATURAL GASOLINE					
1932	3,954	1,318	26	15.38	3.31
1931	3,806	1,268	39	10.09	2.94
1930	6,661	1,110	15	25.76	3.40
1929	5,463	5,463	13	30.39	1.25
1928	2,544	1,272	12	33.96	3.48
1927	3,258	1,629	10	39.65	3.24
PIPE LINE					
1932	14,097	1,762	23	17.31	2.23
1931	16,354	1,363	14	27.32	3.01
1930	17,365	1,447	15	26.40	2.78
1929	20,225	2,022	9	42.50	2.55
1928	10,225	1,025	10	41.58	3.57
1927	9,025	645	6	64.22	5.98

When we stop to consider that approximately 90 per cent of all accidents result from human failures, such as chance-taking, ignorance, haste or mental lapse, we can appreciate the importance of training the worker in safe practices as well as the magnitude of the task that faces the supervisor.

Of first importance in getting the worker in the proper mental attitude for winning his support to the safety cause is to get him to understand the seriousness of accidents and to appreciate his responsibility to his family, his fellow worker and himself. The progressive supervisor will not be so rushed but that he will find time to explain to the new man the company's safety policy and to impress upon the worker the fact that accident prevention is an individual problem for which each man is responsible.

The next step in getting the man started right on the job is that of introducing and instructing him in the work. Where a new man is to be assigned with a group, the supervisor should show both the new man and the other workers the courtesy of an introduction. This eliminates to some extent the feeling of fear and uncertainty usually experienced by the new man; and if the group is introduced to the new employee, they are at least on the way to establishing friendly relations. The next task confronting the supervisor is that of instructing the man in the work he is to do and explaining to him right and wrong methods. This is necessary even though the worker says he is experienced or the work is of such simple nature as digging a ditch.

It is because some supervisors feel that their job of accident prevention is done when they tell the workers of the hazards of the job and quit here, that many accidents still occur. Workers, new and experienced, must be observed closely so that chance-taking, and unsafe practices may be detected and corrected before the accident occurs. The title of supervisor implies that the foreman, gang pusher or farm boss serves in the capacity of supervising the work of others. It is his job to observe, to direct and to correct so that the job may be accomplished safely and efficiently.

No other individual can "step in" and do the supervisor's job of training the worker. However, assistance can and should be given by the accident prevention department in distributing instructive information and stimulating interest.

Methods of organization for accident prevention may vary as to hazards and conditions in each company, but any program that takes into consideration advanced engineering principles in design and layout, maintenance of equipment, and training of the worker as to safe practices, will experience not only a lower accident frequency but will develop a loyal and efficient organization as well.

Design of Marine Oil Terminals

Article II.

By M. C. COCKSHOTT

Design and Consulting Engineer

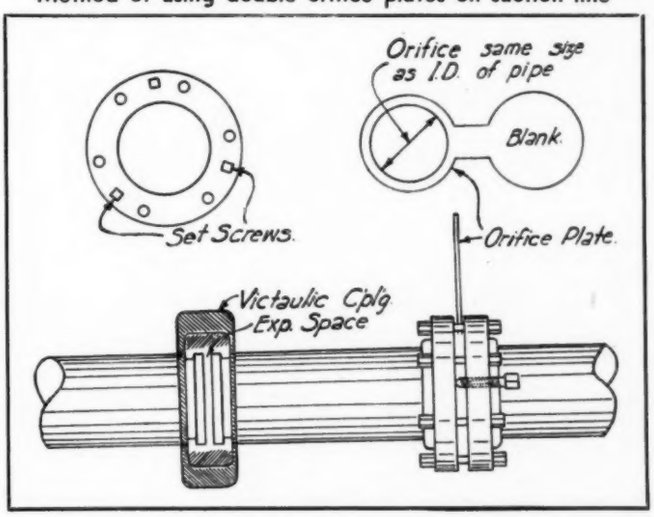
IN a previous article the design of oil marine terminal docks, tankage and firewalls were discussed. Next to consider are pipage facilities and the pump house. All lines entering the tank must have provision for movement of both line and tank, and a full swing is recommended, which can be very efficiently made up by the use of flexible couplings. It is good practice to have all lines, both in the tank farm and dock, sloping toward the pump house so that they can be emptied if needed; however, some companies make it a practice to have wet lines all the time, that is on the suction side. On the pump discharge to the dock the lines are always full before starting the pump, and are left full when the tank is loaded. Welding of all piping in the tank farm is now almost universal practice, as all leaks are obviated by using this method, more especially in handling gasoline. To take care of expansion in a long run of piping, expansion sleeves must be provided, however, in handling gasoline there is a danger of leaks, and even a chance of the coupling pulling out. This can be prevented by means of a bar welded to the pipe and allowed to slide through a clip, but the flexible coupling, though not allowing so much expansion per coupling, is more satisfactory if used, say on each 60 ft. of pipe run. The amount necessary can be figured very easily and sufficient couplings used to take care of the expansion. A relief valve set on the suction lines, or any line that is likely to remain full of gasoline or oil should also be installed with its relief side piped into a tank to obviate waste.

The black oil tanks are usually fitted with steam coils so that in cold weather the oil may be warmed up for a better flow through the lines, thus reducing the viscosity. It is also advisable to have a steam connection on all black oil lines, so that if necessary they may be cleared with hot steam. The steam line, usually a 6-in. line, should be well insulated and provisions made for expansion, either with a sleeve or bend. Where the steam comes from the coils, there should be a return trap system, whereby the steam is trapped and the condensate returned to the hot well. Some tank farms in connection with a terminal have what is called a ballast tank; this is a tank to take care of any slop water that the ship may wish to dispose of, the dumping of this into the harbor usually being prohibited on account of polluting the water with oil. This tank is fitted with a system of skimming pans, whereby the oil may be skimmed off the ballast water, and run into an oil sump. This oil sump takes the drains from tanks and any other drains that contain oil, and is usually fitted up as a separator, whereby the oil may be drawn off and the water, cleansed of oil, returned into the harbor through the plant sewer. There should be no possiblity of black and white lines being connected. If, in the event of a present white line having to go into black service at a later date, a spool should be placed in the line and removed when the change over is made; valves are not to be trusted, as the human element is there, and a mistake will be made sooner or later. In a new terminal that was built for oil and gasoline service, but for a time was to be used all on gasoline, and then converted over, a few double orifice plates were used on the suctions. One plate was blank, the other had an orifice in it, the plate in use being held in place by flanges. By means of set screws in the flanges, the short length of pipe may be forced into expansion space in Victaulic coupling sufficiently for withdrawing of orifice plate. With the blank side in, there was no chance of mixing the products, however, if it can be avoided there should be absolutely no mixing of black and white lines. At the pump house, which should be located at the water front and close to the dock, all pumps should be placed so that there is always a positive head on the pumps, with no chance of air pockets in the high spots; if this is unavoidable, they should be properly vented.

Centrifugal pumps are invariably used on gasoline and light oils, and either a rotary or screw pump on heavy gravity crudes and fuels. With the former types of pumps it is essential that the suction pipe be brought horizontally into the pump, or else a run of at least 12 in. be provided before an ell is used, as the liquid will tend to throw the impellor out of balance if, due to a bend too near the pump, the oil hits it on one side. In some installations there is a service pump, usually of the reciprocating type, used to drain lines, handle water to tanks, put water up to the roofs, and for clearing the way if a line is plugged up on the tanker's inlet system. This pump has its own manifold, and can be rigged up for any purpose desired, even as an auxiliary for bunkering small craft or barges, when the main pumps are in use.

In most cases the pumps in a terminal pump house are connected to their prime movers through a firewall between the motor room and pump house. There is a stuffing box in the walls, thus precluding the possibilities of vapors leaking into the engine room. However, in some cases, if explosion-proof motors are used, this

Method of using double orifice plates on suction line



may be dispensed with, but the cost of explosion-proof fittings may be high compared with that of a firewall that the latter is more generally used.

It should be possible to stop the motors at the dock, and in some cases are installed so that they may be started by remote control. This can be extended further by making it possible to stop and start all pumps from the tank farm also, however, this is a refinement that is rarely needed. Local fire ordinances will indicate where vapor-proof and explosion-proof fittings may be used, usually everything around the plant must be of the former type, with the latter where there is a real danger of heavy gasoline vapors.

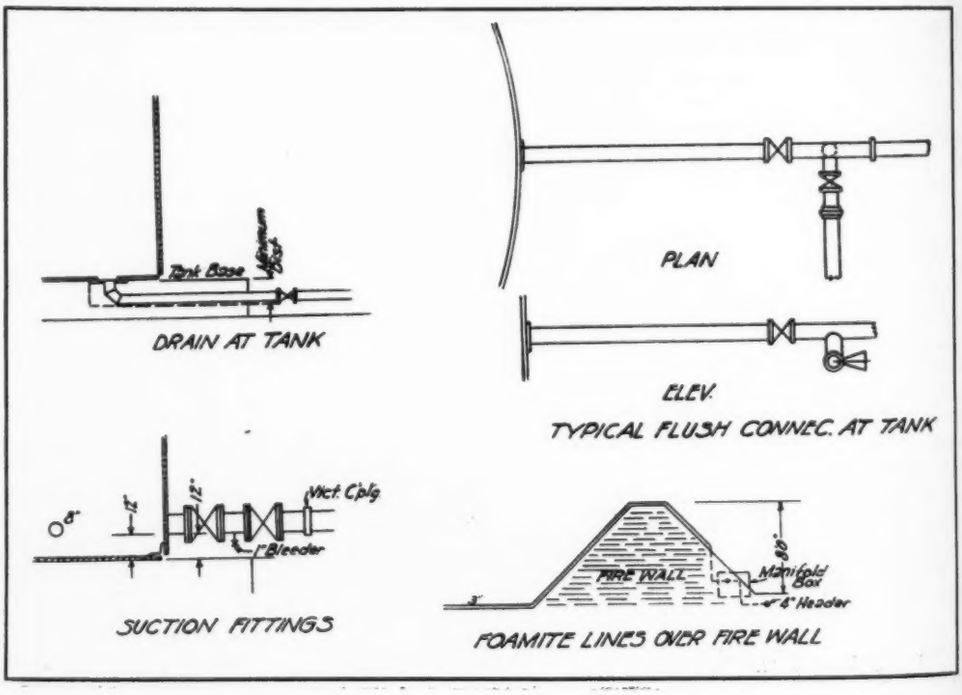
In the pump house the piping can all be of welded construction, bearing in mind however that due provision is made for removal of pumps and valves for repairs and overhauling. Each pump should have a pressure guage on both suction and discharge sides, the one on the former side showing inches of vacuum. These can be mounted on a board, or else be placed right at the pump. In designing the piping, consideration must be given to the viscosity of the oils that are to be handled, a very considerable saving in motor horsepower can be effected by allowing the line to be of large size. In so far as the pumps are concerned, if complete data are furnished the pump manufacturer, they will prescribe the correct pump for the job, which can be checked as far as line sizes, etc., are concerned. With pumps of high efficiency there is little trouble to be expected from this source, however, it is wise to have the pump people look over the final layout, before the order for pumps is placed. This will frequently obviate a lot of argument later, as there will be no grounds for excuse that anything has been omitted in the data supplied them. The location of the boiler house will usually be on the extreme edge of the property, away from danger of vapors, and of necessity entailing a long run of steam line, with due provision for expansion. The horsepower will, of course, depend on the size of the coils in the oil tanks, and also on the predicted amount of steam necessary to carry the auxiliaries on the tanker. For the average terminal of around 250,000-bbl. capacity two 150-hp. boilers of the horizontal return tubular type are sufficient, usually one on the line at a time being enough.

The office of the plant is usually one on the line at a dock and pump house, and should have a separate room for gaugers and their equipment. There is quite a bit of office work entailed, so the quarters should be airy and well lighted, with a small private office for the superintendent, complete with telephones, intercommunicating phones around the plant, buzzer system, etc.

Some plants are fitted with a special fire-alarm system, whereby they are tied into the harbor fire department, in addition to their own system. So far as fire prevention goes, there are one or two systems on the market that are approved by the board of fire underwriters. In putting in one of these systems, the underwriters will supply an engineer who will prescribe what is needed, usually in conjunction with the local fire department. The Foamite dry powder system is coming into more general use, and is much less expensive than the old wet system. All that is needed is a special duo-mix hopper, tied into the water service, using a pressure of about 80 pounds. There is usually a connection whereby in case of fire the fire engine can boost up the pressure of its own pump. Usually there is a water system for fire, with hydrants, and here also a connection is installed for the fire department to tie into and boost the pressure when needed.

In regard to construction costs, it is rather difficult to estimate in general. A first class terminal with all the necessary auxiliaries will average about $2.00 per bbl. of capacity. By the use of salvaged material, and with the advantage of the present prices it has been possible to build a very efficient small terminal for about half this figure. Neither of these prices take into consideration the cost of the property, or of pipe lines from the refinery. The general use of welding has tended to cut the costs very considerably, and by using good judgment as to when to weld and when to buy fittings, a saving can be effected.

Another factor that has been mentioned in this article from time to time is local ordinances. In this class of service, which is of a hazardous nature to the surrounding country on account of fire, there are usually many angles that present themselves that have to be settled with the local harbor authorities, and before attempting to start work all plans are usually to be passed by various boards of building and fire commissioners. Much grief and trouble can be avoided by having a clear understanding as to what is going to be done before starting it.



Piping sketches for marine oil terminal

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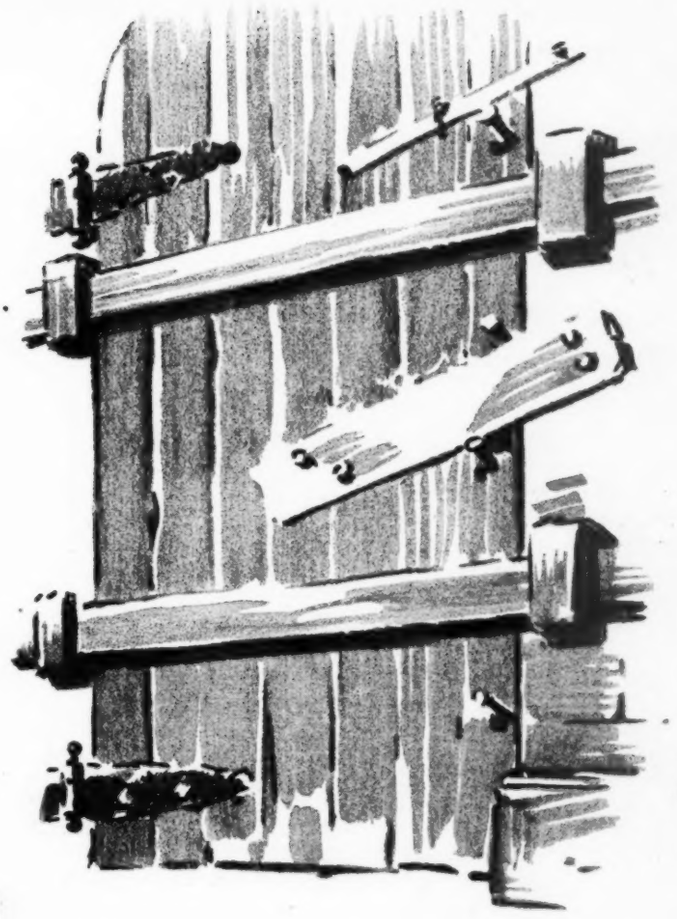

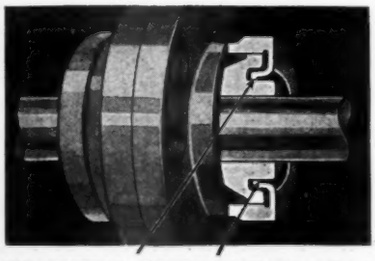

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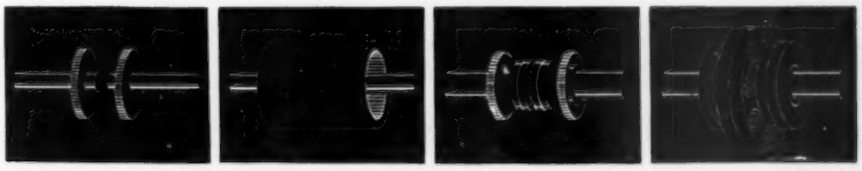

A spur gear on each shaft end, permanently meshed with the internal gears of a floating sleeve. Oil, under centrifugal pressure, transmits the load. All forms of normal shaft misalignment are compensated for between the oil-cushioned faces of the gear teeth. Being "double-engagement" it handles both parallel and angular misalignment smoothly and noiselessly.

Electrical Equipment and Maintenance in Refineries

By
XENOPHON D. IDES
Electrical Engineer

Adequate records and systematic inspection are key to low maintenance and repair costs

IN a large organization, such as that of modern refineries, involving a multiplicity of processes and departments, the electrical system is complex, and memory cannot be relied upon to furnish a general or a detailed picture of the installation and its condition. Detailed electrical records, therefore, become of paramount importance, as they constitute a means of ready and quick reference at all times, and permit any competent person quickly to acquire a working knowledge of the electrical installation. In general, these electrical records can be classified under the following headings: (1) Single-line diagrams, both primary and secondary; (2) Maps showing duct, manhole and cable or aerial lines, with necessary manhole or other sections showing the identified cables in their respective physical locations at these points; (3) Detailed control wiring diagrams of automatic and important circuits as well as of switchboards, and (4) Miscellaneous electrical equipment layouts, lighting layouts, building or power house conduit runs, etc. It is not the purpose of this article to describe the technique of preparing such records further than to say that the nearer they approach the thoroughness and the systems developed and used by our larger consulting engineering and electric power companies, the more useful they will be to the personnel in charge of electrical maintenance and construction.

The efficient and economical maintenance of the electrical equipment in a large refinery can be accomplished only by the creation of an efficient and dependable electrical force. Hence the importance of setting up high standards of personal dependability, natural inclination to shoulder responsibilities, and a desire on the part of the men not only to perform their work well and expeditiously, but also to improve their status and knowledge by outside study. Such men are worth their hire, and when they are found in any plant they should be encouraged in a material way.

Workmanship, and the selection of the proper equipment are absolutely essential if maintenance costs are to be reduced to a minimum and have a healthy psychological effect on the personnel that still further enhances their value. Where strict supervision is not exercised, contractors may not always furnish the best of material, labor or workmanship. The work may be done in any old fashion, and equipment furnished that does not always come up to standard. Too much cannot be said regarding the importance of installing rugged equipment from the outset, and installing it well. The increased initial cost will be many times repaid in reduced maintenance charges.

Undoubtedly, the most economical motor and control equipment maintenance system that can be introduced in any given organization is the one in which the cost of labor and materials balances the cost of possible shutdowns and hazards caused by equipment failures, and the deterioration of the equipment resulting from such neglect or lack of upkeep. It is not possible to determine quantitatively and in advance this balance or relationship, hence good judgment must be exercised by those who are intrusted with this work. Every organization has its own problems to solve, and any procedure that may prove a perfect arrangement for one concern or department may prove entirely superfluous or inadequate for another. However, one can be guided by systematically observing over periods of time the performance and the conditions affecting any given piece of apparatus. From such observations inspection schedules can be formulated and altered from time to time, thereby giving reasonable assurance that any piece of electrical equipment is neither over- nor under-inspected. Obviously, in a large organization where there is a great variety and quantity of electrical equipment to be taken care of, a system of some sort must be introduced that will enable those in charge instantly to determine not only the maintenance history of any given piece of equipment, but also to ascertain the progress of the work on the basis of schedules previously formulated. Such a scheme would naturally involve a certain amount of paper work, but this can be simplified to such an extent as not to make it objectionable.

In attacking the problem of motor and control equipment maintenance, it is necessary that lists first be prepared of the equipment in the various departments throughout the plant. In gathering this information, notations can be made of the apparatus as connected in the general circuit in any given department, and from these data departmental or feeder single-line diagrams can be prepared. The nameplate data thus obtained are then incorporated in motor and control equipment sheets on which proper fuse ratings and thermal relay settings are specified for the future guidance of all concerned. A typical example of the data contained in these sheets is shown in Figs. 1 and 2. These sheets are prepared in pencil to permit easy erasing when motors and controls are removed from any department. Blueprints or photostatic copies are then prepared, and when the sheets for all the plant departments are bound together, they place at the finger tips of the engineer or the electrical foreman all the necessary data on the motors and controls installed. They also form the reference point from which three sets of extremely useful records are developed. The first of these is the plant motor list, which is nothing more than a convenient rearrangement of the various motor data contained in the departmental motor sheets on the basis of their numerical order as shown in Fig. 3. This list is supplemental and does not supplant the motor card index where more detailed information regarding the history of the motor and other pertinent facts concerning it are given. The usefulness of this list lies in its compactness and suitability for ready reference. The second set of records is a tabulation of the motors on the basis of their horsepower and speed ratings as shown in Fig. 4. In a large plant, containing hundreds of

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Dresser Cast Split Sleeves, Style 26, will repair broken bells on cast-iron pipe. Rubber side-and-end gaskets, specially designed and compounded, simplify the job and insure permanence.

Dresser Cast Couplings, Style 53, can be furnished for A.G.A. cast-iron pipe up to and including 30-in. (For larger sizes, Style 38 Steel Couplings are used).

You will avoid maintenance expense on gas lines and mains if you construct them with plain-end pipe and Dresser Couplings. Vibration, expansion, contraction, shifting soil will not lessen the flexibility nor affect the permanent tightness of the joints. You can expedite the making of repairs to all gas lines and mains by using Dresser Clamps, Sleeves, and Fittings. Emergency repairs can be made without shutting off the service.

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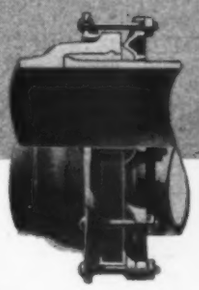

Dresser Bell Joint Clamps, Style 4½-HP, offer an effective and permanent means of repair for all leaking bell-and-spigot joints.

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FIG. 1—MOTORS

Department: Contact Neutralizing Plant. **Sheet 1 of 1.** **Wiring Diagram: W-14-20.** **Location Drawing: M-697**

Designation of Driven Equipment	Motor No.	HP.	Motor Amps.	R.P.M.	Type	Frame	Form	Model	Manu-fact'r	Temp. Rating	Voltage	Phase	Freq	Date Installed	Serial No.	Remarks
Agitator Charging Pump No. 1	1202	10	25–12.5	1800	EX	324	B	Class 63G	L.A.	55C	220–440	3	60	6–1–30	164242	Explosion Proof
Thickener Agitator	1227	5	12.8– 6.4	1800	E	254	B	Class 43N	L.A.	55	220–440	3	60	6–1–30	165653	" "
Vacuum Pump	1204	20	54–27	900	EX	405	B	Class L	L.A.	55	220–440	3	60	6–1–30	166464	" "
Clay Mixer	1322	20	52	1200	EX	404	B	Class L-83-S	L.A.	55	220	3	60	6–1–30	164243	" "
Finished Oil Pump	1200	7½	18.9	1800	K	284		5K-284-B-987	G.E.	55	220	3	60	6–1–30	KH-2613	" "
Water Pump	1313	5	14.1–7.05	1200	K	284		5K-284-A-994	G.E.	55	220–440	3	60	6–1–30	KH-2712	" "
Blotter Feed No. 1	1300	10	26	3600	EX	324	B	Class 63C	L.A.	55	220	3	60	6–1–30	161596	" "
Exhauster No. 1	1400	3	9.5	900		284		Style 750782X	West.	55	220	3	60	6–1–32	8162000	" "
Dryer No. 1	1405	30	80–40	900	EX	445-S	B	Class 5935	L.A.	55	220–440	3	60	6–1–30	165654	" "
Evapcrator Pump No. 1	1329	25	75	600	EX	504	B	Class L-102-T	L.A.	55	220	3	60	6–1–30	161797	" "
Charging Room Exhaust	1331	½	1.66–.83	1200	E	204	A	Class 22-L	L.A.	55	220–440	3	60	6–1–30	168952	" "
Mixer Room Heater Fan	1128	⅙	.58	1800	E	204	A	Class 22-L	L.A.	55	220	3	60	6–1–30	162679	" "

FIG. 2—CONTROL EQUIPMENT

Department: Contact Neutralizing Plant. **Sheet 1 of 1.** **Wiring Diagram: W-14-20.** **Location Drawing: M-697**

Designation of Driven Equipment	Motor No.	HP.	Motor Amps.	Disc. Device	Size in Amps.	Size of Cutouts	Size A Type of Fuses	Starting Device	Manu-fact'r	Cat. No.	Type of Over-load Device	Cat. No.	Rating in Amps.	% Setting	Remarks
Agitator Charging Pump No. 1	1202	10	25–12.5	Saf. Sw.	60	60	60R	CR-7006-D-7	GE	1773151-G-2	CR-2824-TC-121-C	2019557-G-18	30	92	UVTD Push Button CR-2940-BS-82-G-120
Thickener Agitator	1227	5	12.8–6.4	" "	60	60	35R	" -D-7	GE	" -G-2	" "	" -G-15	16	88	" " " " "
Vacuum Pump	1204	20	54–27	" "	100	200	150R	" -D-7	GE	" -G-2	" "	" -G-21	65	100	" " " " "
Clay Mixer	1322	20	52	" "	100	200	150R	" -D-7	GE	" -G-2	" "	" -G-21	65	90	" " " " "
Finished Oil Pump	1200	7½	18.9	" "	60	60	60R	" -D-7	GE	" -G-2	" "	" -G-17	25	83	" " " " "
Water Pump	1313	5	14.1–7.05	" "	60	60	45R	" -D-7	GE	" -G-2	" "	" -G-16	20	80	" " " " "
Blotter Feed No. 1	1300	10	26	" "	60	60	60R	" -D-7	GE	" -G-2	" "	" -G-18	30	92	" " " " "
Exhauster No. 1	1400	3	9.5	" "	30	30	30R	" -D-30-B	GE	4381269-G-3	Heaters 81-D-26		10		" " " " "
Dryer No. 1	1405	30	80–40	" "	200	200	200R	" -D-31	GE	3652800-G-3	CR-2824-TC-121-D	3652500-G-46	90	98	" " " " "
Evaporator Pump No. 1	1329	25	75	" "	200	200	200R	" -D-7	GE	1773151-G-2	" 121-C	2019557-G-22	80	103	" " " " "
Charging Room Exhaust	1331	½	1.66–.83	Fuse		30	6R	CR-2960-SY-105-N	GE	2233554	Thermal Cutout	256916	1.5		
Mixer Room Heater Fan	1128	⅙	.58	"		30	3R	" "	GE	"	" "	256913	.8		

FIG. 3

HP.	R.P.M.	Amps.	Volts	Type	Frame	Form	Model	Temp.	Serial No.	Manufact'r	Designation of Driven Equipment	Location	Motor No.
10	1200	25.3	220	KT	956	C	400040	40	4598349	G.E.	Air Compressor	B.F.	921
200	1800	42	2200	ATI	160M	S		50	4096151	G.E.	Water Pump	Wax	922
5	900	15	220	KT	751	C		50	3989662	G.E.	Pressed Oil Pump	Wax	923
5	900	14.9	220	KT	952	C	400056	40	4136402	G.E.	Hot Oil Evaporator	AE	924
15	1200	38	220	KT	502	B	18158	40	4326499	G.E.	Water Pump	AE	925
10	1200	25.3	220	KT	956	C	400040	40	4604258	G.E.	Water Pump	AE	926
3	3600	8.0	220	CSA	827		38948	40	3926414	West.	Centrifuge No. 1	Cent.	927
3	3600	8.0	220	CSA	827		38948	40	3926411	West.	Centrifuge No. 2	Cent.	928
15	1200	38	220	KT	502	B	12-C-680	40	4821026	G.E.	Water Pump	Dist.	929
100	1800	23	2200	KT	543	EL	17472	40	5168705	G.E.	Water Pump	Wax	930
125	327	28	2200	Synch.				50	4670163	West.	Air Compressor	L.O.	931
7½	1800	18.6	220	KT	944	C	400016	40	4429963	G.E.	Oil Pump No. 1	Comp.	932
												Junked	933
7½	1200	20	220	KT		C		40	1532466	G.E.	Ammonia Comp.	Lab.	934
													935
													936

motors, is often necessary to obtain quickly a motor to replace burned-out or defective equipment. By referring to this list one can at a glance determine the particular motors that have the required horsepower and speed ratings and their location in the plant. By a small amount of cross-reference work it can soon be determined whether or not the frame numbers, and therefore the dimensions, of any of these motors will permit ready installation in the emergency location, and whether they are available for transfer. Or if the right motor is not available, the list can be examined for a motor of the next lower or higher speed or for one having a different rating but the same frame number. For this purpose, it is suggested that a supplementary tabulation be prepared, listing motors also on the basis of their frame numbers.

The third set of records prepared from the departmental motor and control equipment lists, is comprised of the departmental individual motor and control equipment sheets shown in Figs. 5 and 6. After the necessary identifications and instructions have been entered on these sheets, they are arranged in numerical order on the basis of the motor tag numbers, the control equipment sheets being placed with the corresponding motor sheets, and the entire group of any department bound with staples in stiff, serviceable, but not necessarily expensive, fibre binders. These books, together with such useful information as a departmental single-line diagram, a motor and control equipment list, and typewritten instructions on what to look after in inspecting equipment, are handed over to the various inspectors or maintenance men. As each motor and control is inspected the necessary entries are made in ink or pencil under the various headings. The reverse side of each form is left blank for entries that require more space or are of unusual nature. In order to facilitate the inspector's work, a "ticklet" form has also been developed, and a few of these sheets form the first few pages of each book. As will be noted by referring to Fig. 7, these sheets contain a series of columns for making entries of dates when motors and controls have been inspected. By scanning these dates the inspector or foreman can at a glance determine the status of the maintenance work in any given department. The books from the various inspectors are turned in every two weeks for the foreman's or engineer's review and comments. All this paper work is further supplemented by occasional inspection tours by the responsible head of the electric department. The number of motors assigned to each inspector will naturally vary in each organization, and will depend upon their location, size, the importance of the drives, and the frequency of inspection required. A dependable inspector should be capable of handling anywhere from 100 to 250 motors without any difficulty, provided, of course, that the installation is not in a rundown condition, and that a small flying squad of electricians is available to render assistance whenever breakdown or other service conditions require.

The frequency with which any given piece of electrical apparatus has to be inspected depends considerably upon the service, the type of the equipment, and the surrounding conditions. Each case has to be analyzed on its own merits and inspection frequencies changed as conditions warrant. The entries on the maintenance sheets over given periods of time, as well as the recommendations and observations of the in-

FIG. 4

Size of Motor: 10 H.P. Sheet 1 of 1. Page

3600		1800		1200		900		720			
Motor No.	Loc.	Motor No.	Loc.	Motor No.	Loc.	Motor No.	Loc.	Motor No.	Loc.	Motor No.	Loc.
1300	CN	59	AE	551	Filter	67	Wax	917	Dist.		
1307	CN	1219	Cent.	686	AE	470	Wax	918	Dist.		
1250	HPS	1220	Cent.	687	AE	1095	Wax	11	B.P.		
1251	HPS	975	Cent.	201	BF	205	B.S.	302	B.S.		
		1202	CN	200	BF	646	Comp.				
		1201	CN	202	BF	645	Comp.				
		1203	CN	921	BF	459	Comp.				
		1215	HPS	961	Can.	1503	GK				
		1211	HPS	1038	Can.	299	Dm.W				
		1213	HPS	959	Can.						
		1255	HPS	998	Can.						
		1256	HPS	1194	Comp.						
		621	B.S.	960	Comp.						
		620	B.S.	22	B.S.						
		583	B.S.	18	B.S.						
		581	B.S.	1161	Comp.						
		501	B.S.	1289	Farm						
		750	Water	1290	Farm						
		995	Spare	1123	Spare						
		1218	P.H.	1124	Spare						
		1217	P.H.	836	P.H.						
		755	P.H.								

spector, will form a fairly good index on which to base such decisions. Where explosion-proof or totally enclosed ball-bearing motors are installed, they cannot be inspected frequently for armature-rotor clearances as they cannot be dismantled readily; the motors themselves, however, are so well protected from external deteriorating influences, that frequent inspection is not so necessary. All one can do in such cases is to see that they are kept clean, free of drippings, vibration and overloading. Hence an inspection once every four to six months should be sufficient. At points that are considered hazardous, open-type motors should be inspected at least twice a month. At other points, inspection every two or three months should suffice, provided there are no external deteriorating influences that make closer watching necessary. The frequency of inspection on the starting equipment depends upon the severity of the service to which it is subjected as well as its location in the plant. Obviously, a contactor capable of handling a 15-hp. motor but controlling instead a 3-hp. motor with infrequent starting and stopping, will not require so much maintenance and care as when controlling a 10-hp. motor with more frequent starts and stops. At points that are not considered hazardous, starters need not be inspected oftener than once every three months, except to see that they are kept clean and free from moisture or oil drippings at all times. A great deal of judgment must be exercised in determining inspection frequency schedules, and no hard and fast rules can be set down on this matter. Even after schedules have been formulated, they cannot always be followed to the letter, for quite often, process requirements and other unavoidable conditions may make it impossible to adhere to schedules. There is no harm in occasional delay, the important thing is to remember that equipment should be inspected at fairly regular periods and that the system should not be abused as a result of such delays.

In general, the electric motor is a sturdy prime mover, and a motor and its control equipment with proper care should give almost indefinite service. The importance of taking good care of and conserving all the electrical equipment and material installed should become more apparent to plant executives when it is realized that an investment of at least $25.00 has been made for every horsepower of electrical equipment in use, including transforming, transmitting, control and motor equipment, and exclusive of the still larger investment in generating plant.

Labor is such a predominating item of maintenance cost that slight over-motoring, and the installation of sturdy control equipment even for small motor applications will pay for themselves in the long run in reduced outlay and maintenance costs. The reduction in power factor consequent upon such a policy very easily can be compensated by other well-known means.

The average conditions that bring about motor deterioration and failures may be summed up as follows: (1) Wear in bearings caused by improper application, faulty lubrication, and dirt or grit in oil wells and bearings, and (2) Deterioration of windings due to oil, dirt, dust, acids, moisture, overheating, etc.

In the case of the control equipment the conditions that bring about trouble are excessive heating of contacts and coils, pitting, lack of oil, overfusing, improper overload protective equipment, dirt, oil, moisture, etc. If the proper precautions are taken the existence of these conditions can be prevented. Even with the best of care, motors and controls, and other electrical equipment may occasionally fail; such failures, however, should not detract from the value of systematic electrical equipment inspections, as in their absence the number of failures would be greatly multiplied.

FIG. 5

Motor Maintenance Record

Location of Driven Equipment—C. N. P. No. 1 Agitator Charging Pump								Tag No. 1202
HP	RPM	Volts	Amps.	Mf'c't'r	Type	Frame	Form	Model Class	Serial No.
10	1800	220	25	L.A.	EX	324	B	63G	164242

Phase	Freq.	Temp.	Remarks:	Inspection Freq.
3	60	55		4M

Inspection Date	Gen. Appearance	Temp. by Touch. Bearings	Temp. by Touch. Stator	Coupling	Rotor-Stator Clearances Upper	Lower	Left	Right	Vibration	Windings	Commutator	Motor Dismantled	Megger	Oil or Grease in Bearings	Motor Cleaned	Brushes	Remarks	Inspector

FIG. 6

Control Equipment Maintenance Record

Location & Driven Equipment—C. N. P. No. 1 Agitator Charging Pump				Motor Tag No. 1202
HP	Volts	Amps.	Control Equipment & Mfc't'r	Wiring Diag.	Inspection Freq.
10	220	25	G.E. Contractor CR-7006-D-7	W-14-20	2M

Overload Device & Setting		Disconnecting Device & Fusing
Th. Relay CR-2824-TC-121-C,	92% 30 Amp.	Safety Sw.—60A Regular

Inspection Date	Gen. Appearance	Setting of Relay	Contractor Tips before Inspection	Work Performed on Cont. Tips	Control Circuit Operation	Heating of Control Equipm't	Condition & Heating of Switch & Fuses	Changed Oil			Remarks	Inspector

FIG. 7

Inspection Record: Motors and Control **Dept.: Contact Neutralizing**

Driven Equipment	Motor	Insp. Freq.		Inspected on				
Mixer Room Heater Fan	1128	M	4M	3-20-32	8- 1-32	12-15-32		
		C	2M	3-20-32	5-15-32	8- 1-32	10- 3-32	12-30-32
Finished Oil Pump	1200	M	4M					
		C	2M					
Agitator Charging Pump No. 1	1202	M	4M					
		C	2M					
Vacuum Pump	1204	M	4M					
		C	2M					
Thickener Agitator	1227	M	4M					
		C	2M					
Blotter Feed No. 1	1300	M	4M					
		C	2M					
Water Pump	1313	M	4M					
		C	2M					
Clay Mixer	1322	M	4M					
		C	2M					
Evaporator Pump No. 1	1329	M	4M					
		C	2M					
Charging Room Exhaust	1331	M	4M					
		C	2M					
Exhauster No. 1	1400	M	4M					
		C	2M					
Dryer No. 1	1405	M	4M					
		C	2M					

Dial Thermometer

C. J. TAGLIABUE MANUFACTURING COMPANY, Park and Nostrand Avenues, Brooklyn, N. Y., announces a new 5-in. dial indicating thermometer in a black bakelite case. This instrument was developed to meet the demand for a moderately priced dial thermometer that stands up under severe operating conditions.

The new TAG Dial Thermometer has an exceptionally powerful moving element or bellows suited to certain commonly used vapor tension ranges between minus 40 and plus 335 deg. fahrenheit.

The indicating pointer is actuated by the motion of bronze bellows, which

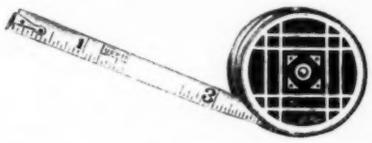
expand and contract at the slightest temperature change at the bulb. This powerful motion is transmitted directly to the pointer by a new vibration-proof connecting mechanism.

Strikingly neat in appearance, the black bakelite case serves as a perfect contrast for the large clear-cut white numerals of the jet black 5-in. dial. With the instrument case mounted at a convenient distance to face the operators, the pointer of the TAG Dial Indicating Thermometer can be read as easily and surely as the hands of a clock.

A special bulletin No. 1050 has been prepared by the Tagliabue Company and will be sent upon request.

Lufkin "Aristocrat" Tape-Rule

ARISTOCRAT NO. 186 TAPE-RULE, just put out by the Lufkin Rule Co., Saginaw, Michigan, combines beauty with unusual utility. It is a practical 6-ft. measure for general



work, yet weighs but two ounces and has case but 1⅝ in. in diameter, and therefore appeals to executives, salesmen and many others who wish a handy pocket measure.

The steel line, which is stiffened by special forming, can be projected unsupported, like a rule, to walls or into openings, yet will also flex around and accurately measure circles, etc. It is manually operated. Hook at first end is very handy when measuring, either within or beyond arms reach. No. 186 is graduated 72 inches to 16ths; No. 186D carries in addition engineer's measurement, i.e., feet, 10ths and 100ths of feet.

The case is of stainless steel, very smoothly formed. Both sides have embossed design with background in black enamel. Individual box is attractive, in black and silver, transparent covered.

Metallic Lead Base Lubricant

A NEW LUBRICANT has been developed in which metallic lead is the protective element. The lead has been broken down into such finely divided parts as to be virtually a soluble or liquid lead within a lubricant vehicle. The new product, known as Bestolife, forms a thin protective film of lead on all contacting surfaces which changes such surfaces to a continuous unbroken, anti-frictional area, according to the manufacturers, Armite Laboratories of Los Angeles. The lubricant has a pure metallic lead base instead of lead salts and is said to be free from chemical reactions. The minimum constituency of lead in Bestolife is 10 per cent, ranging up to 65 per cent, and is claimed to withstand temperatures up to 430 deg. and will not entirely lose its lubricating stability until the melting point of lead is reached, which is 590 deg. The principal application of the product in the petroleum industry is for use as a wire line lubricant, also for tool joint and pipe dope, and pump and valve stem packing, plug cocks, gears, bearings, belt and brake band dressing. The manufacturers have issued a bulletin. Copies may be had by addressing Armite Laboratories, 1450 East 61st Street, Los Angeles, California.

Sucker Rod Guides

WALKER SUCKER ROD GUIDES, developed and manufactured by the Korner Engineering Company of Los Angeles, Calif., are said by the manufacturer to eliminate practically all buckling and slapping of the rods and to have unusually long life. Some of these guides have been run continuously in very crooked holes for more than eight months without showing any appreciable wear, it is claimed.

These guides are entirely different in design from the ordinary type of guide. The fluid passes up through the center of the guides rather than up the outside, thus preventing any obstruction to fluid passage. When guides are placed every 30 ft. on the entire length of the rod, buckling and slapping are said to be eliminated as the guides fit the inner wall of the tubing within 3/16 of an inch.

Walker sucker rod guides are made of a special alloy cast iron base and take a high polish. They are clamped to the rod a short distance from the rod coupling, by four special bolts and are made in two sizes (2½-in. and 3-in.) for any rod up to and including⅞-inch.

Hause Drop and Seat

THE HAUSE VALVE COMPANY of Wichita, Kansas, is offering to the oil industry a Drop and Seat, which has already found considerable favor in many pumping fields.

It has proved its ability to produce a material increase in fluid lifted and gives long service without operating difficulties. The Drop is of sealed, hollow construction, which materially reduces its weight. This exclusive advantage prevents pounding out of the seat. This light weight also allows the valve to open quickly, decreasing the danger of gas lock, and allowing the pump to fill to its full capacity.

The cylindrical design of the Drop also prevents spinning out of the cage. It also has reversible seating surface, which is protected when not in use by a guide on the end of the drop. The design of this drop also eliminates internal stresses, and reduces the danger of distortion.

Actual laboratory tests have proven that the Drop operates without any evidence of turbulence.

The Hause Drop and Seat is made of the best alloy steel, scientifically heat treated, thus assuring maximum toughness and hardness.

A Crawler-Mounted Clean-out Rig

A FIRE-PROOF all-steel gasoline engine-driven spudder, mounted on crawlers, has been brought out by the Keystone Driller Company. The rig is complete and self-contained, and is especially well adapted for cleaning out and abandoning wells. Its most striking characteristic is mobility, the full-crawler mounting enabling it to go anywhere, at any time, where a caterpillar tractor will go. For long distance travel the derrick can be quickly lowered to a horizontal position and grades up to 50 per cent negotiated carrying a full complement of tools and equipment.

When traveling from well to well in the same field, it is not necessary to lower the derrick, the machine having extraordinary stability by virtue of a very low center of gravity. The total weight of machine with derrick is only about 14,000 lb., of which over one-half is concentrated in the crawler assembly.

All fast revolving shafts are mounted on a ball and roller bearing. The crown pulley is mounted on a roller bearing in a sliding frame resting on dual spring shock absorbers, an arrangement which has proved very successful in drilling with wire line without a cracker.

The great compactness of the machine is due partly to all-steel construction, and partly to the employment of chain drives, making possible very short shafts and most efficient placement of the operating parts, including bull wheel and sand reel.

This machine, known as No. 71, is designed for wells up to 1000 ft. deep; while No. 90, another new Keystone spudder of similar design, will drill to a depth of 3600 feet. The latter is equipped with calf reel.

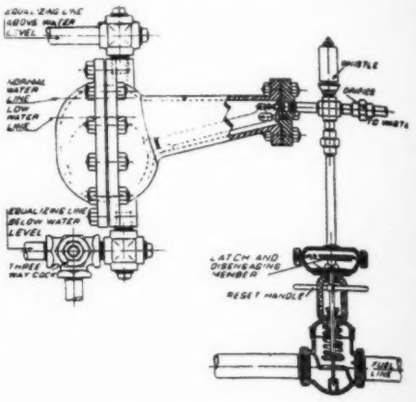
It is claimed that the use of these rigs for cleaning out and abandoning will effect a saving upwards of $500 per well, on account of the great saving of time in getting on location, ready for work, and getting away after the job is completed.

The Keystone Driller Company originated the spudder over 30 years ago, and the essentials of the Keystone spudding principle has since been universally adopted for portable cable drilling rigs, having proved uniformly successful wherever cable tools are suitable.

Protective Unit for Field Boilers

WORKING in accordance with requirements set by the Hartford Insurance Co., engineers of the Davis Regulator Company of Chicago recently developed an automatic low water fuel cutoff that is especially designed to meet insurance standards for gas-fired field boilers such as are used in drilling oil and gas wells.

As shown in the accompanying diagram, the unit consists of a cast-steel float chamber, pilot valve, fuel shutoff valve and a whistle. The float chamber is connected to the steam and water spaces of the boiler so that the minimum low water line will be approximately in the position shown in the diagram. The diaphragm-operated fuel valve may be placed at any convenient point, as it is closed by admission of steam pressure to the top of the diaphragm. The unit is designed to handle a maximum working steam pressure of 350 pounds.



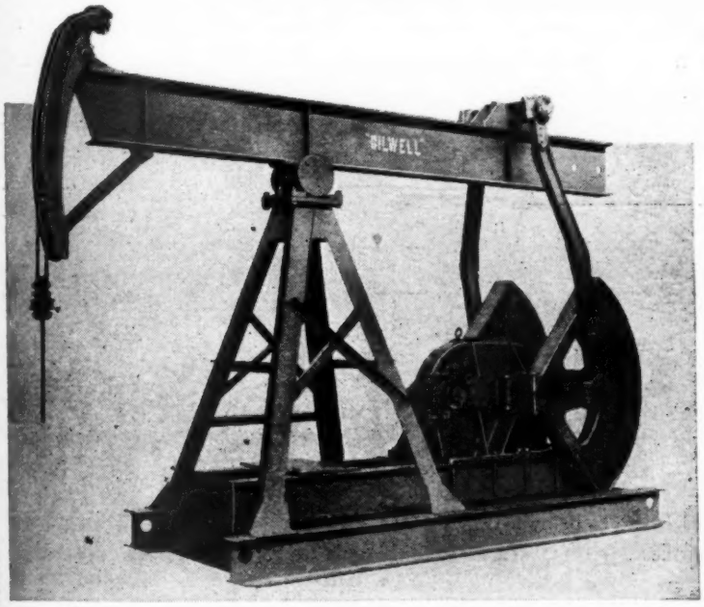
The cycle of operation is simple. When the water level in the boiler drops below a predetermined point the float will be carried down to a point where it opens the pilot valve. Steam flowing through the pilot valve builds up pressure over the diaphragm of the cutoff valve and forces it down. The downward movement of the diaphragm trips a latch and causes the main valve to close immediately. After closing it cannot be opened again until the latch is reset by hand.

A whistle is installed between the float chamber and the cutout valve; when the pilot valve opens the whistle blows, thereby warning the attendants. A small vent orifice is provided in the line between the pilot valve and the diaphragm chamber that prevents any possible leakage from building up enough pressure to trip the fuel valve. The vent is kept very small so that it does not interfere with the regular operation of the unit.

Facilities for testing the unit at any time are provided by a three-way cock located in the water leg of the float chamber. Movement of this cock drains the water out of the float chamber and allows the pilot valve to open, thereby starting the cycle of operation. Steam blowing through the cock after the water is drained out makes it impossible not to notice the position of the handle. This insures the operator that the cock will be turned back to its normal position. As a further safeguard, the main fuel valve cannot be reopened so long as steam flows through the float chamber.

FIELD-PROVEN
UNIT PUMPING POWERS

The illustration shows one of the many "OILWELL" ODH-18 INDIVIDUAL PUMPING POWERS *which are giving reliable and trouble-free service in the East Texas field. This particular Unit is equipped with the new* "OILWELL" SECOND WELL ATTACHMENT *and is doing the work of two individual Units with complete satisfaction.*



Illustrating "OILWELL'S" TC-20 TWIN-CRANK UNIT POWER *having twin counterbalanced cranks. The equalized load on both cranks and pitmans gives smooth, efficient and trouble-free performance in the field.*

THE new "OILWELL" ODH-18 and TC-20 UNIT PUMPING POWERS are sturdy structural-steel Units for efficient and dependable pumping of individual wells. A few of the many outstanding features of these Units are:

Rugged, Arc-Welded, Structural-Steel Construction;

Enclosed, Weatherproof, Oilbath and Grease-packed Bearings;

Wide Range of Stroke Lengths and Speeds;

Gas, Oil or Gasoline Engine or Electric Motor Drive;

Straight-Line Polished Rod Motion;

Adjustable Counterweights;

Convenient Arrangements for Servicing Well;

Fully Enclosed Westinghouse-Nuttall Speed Reducer
with heat-treated helical gears, roller bearings and quick-acting brake.

"OILWELL" ODH-18 and TC-20 UNIT PUMPING POWERS can be furnished with the new "OILWELL" SECOND WELL PUMPING ATTACHMENTS which make it possible to pump two wells with one Unit. Installations with this equipment are performing with complete satisfaction.

Ask the nearest "OILWELL" representative for information on FIELD-PROVEN UNIT PUMPING POWERS.

OIL WELL SUPPLY CO.

Branch Stores in all Oil Fields

SUBSIDIARY OF UNITED U.S. STATES STEEL CORPORATION

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"OILWELL"

Solving Well-Pumping

ARTICLE VI.

« Gears »

THIS article will deal with transmissions between parallel shafts only, and particularly with double helical (usually called "herringbone") and single helical (or spiral) gears.

Much has been published on the subject, but an examination of contemporary textbooks on gearing will soon disclose that the information to be derived from them is mostly of a geometrical or theoretical nature without particular reference to practical limitations and purposes. The inadequacy of textbook information soon becomes apparent. Let us first try to find a practical definition for the purpose of gears.

When we use gears to connect two or more shafts, we desire to impart torsional effort and circular motion from one shaft to another, or to others. We may wish to reduce the speed of the driven shaft or we may wish to increase it in relation to the speed of the driver, but we generally desire to obtain a faithful and undistorted copy of the original motion, multiplied by the gear ratio, without the introduction of superimposed shocks that are self-created by the imperfections in the gears themselves.

Textbooks are usually based on the assumption that gears are geometrically perfect, they give little indication of the consequences of inevitable error, hence those who rely on them for information start with the wrong point of view.

The surviving form of gear tooth is the involute.

Theoretically, the spur gear and pinion with perfect involute teeth, generated and equally spaced around circles which are exactly concentric with their respective axes, will transmit, without distortion or vibration, a perfect reproduction of the circular motion of the driving shaft, except for the desired change in average angular velocity effected by the gear ratio. *Practically,* a spur gear and pinion will do nothing of the kind unless they are produced by laboratory methods that are entirely outside the limits of commercial engineering practice. Even if we assume that perfect gears are cut and put into operation, it is only a question of time and wear before the involute surfaces are destroyed and the action becomes irregular. In short, the spur gear can only function perfectly so long as the *tooth contour* remains perfect. But some wear must always take place and in spur gears this wear must be of such a character as to deform and destroy the original tooth contour, so the maintenance of perfect transmission through spur gearing is practically impossible. The reason is that in the spur gear, simultaneous contact is always in the same phase right across the face from end to end of a tooth.

The line A-B, Fig. 42, represents the commencement of engagement, A-E being the working depth of the tooth. Contact will be gradually transferred to parallel lines from A-B to E-F, assuming that the proportions of gear and pinion bring the entire working depth of the tooth within the line of action. The pressure transmitted will be uniform with uniform load. While contact is traversing the hatched area, A, C, D, B, the teeth of gear and pinion are sliding across each other under pressure—at first at A-B, then more slowly until *rolling* contact, without sliding, occurs while the tooth engages at the pitch line, C-D. After contact passes C-D, sliding recommences, but in the reverse direction and with continually increasing velocity, until engagement ceases along the tip of the tooth E-F. Since different parts of the involute surface, A, C, E, F, D, B, are subjected to the same pressures under different conditions of rubbing and lubrication, it is fairly obvious that different degrees of wear must take place, resulting in *constantly changing contours.* The preservation of the involute contour is necessary if the spur gears are to function in the manner which theory demands.

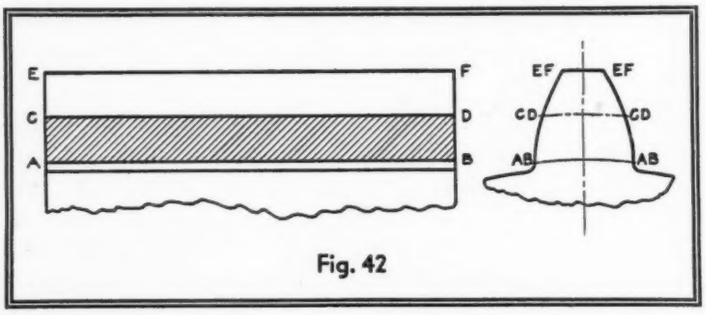

Fig. 42

Within certain limitations the double helical (herringbone) gear does *not* depend on the preservation of a true involute tooth contour in order to perform, in a practical and enduring manner, the functions of a theoretically perfect gear, and this is the fundamental reason for its success.

In the illustration, Fig. 43, a double helical gear is assumed to be in engagement with a pinion over a zone of engagement represented by the rectangle, P, Q, R, S. The direction of motion is shown by the arrow on left. For simplification, the gear is shown in development (like a rack) and the engaged sides of the teeth are shaded. Tooth 1 is just coming into engagement, teeth 2, 3 and 4 are fully engaged over their working depth, while tooth 5 is just coming out.

The usual explanation for the relatively smooth action of the herringbone gear as compared with the spur type is that simultaneous transference of engagement from tooth to tooth is substituted by gradual (helical) transference of an actual instead of circumferential character. But this is only a part of the story. Provided the face width of a herringbone (or helical) gear bears a certain minimum relationship to the circumferential pitch of the teeth and the spiral angle of the

Equipment Problems

By HYMAN LEDEEN
Engineer-in-charge, Western Division, The Falk Corporation, Milwaukee, Wis.

helix, there will always be at least one tooth on each helix that is in contact at the pitch line.

Next, provided the tooth contours are of such a nature that no point in any tooth is outside of the involute curve through the pitch point, such gears, if accurately divided, will fulfill the required conditions of smooth transmission. In Fig. 44 the full line represents a perfect involute tooth with pitch point at A. The dotted line is a "near involute" tooth that coincides with the other at point A and over a zone on both sides of it but lies inside the involute curve at tip and root. Teeth cut in this manner will show a bearing over the shaded portion and, in the case of helical teeth (herringbone gears), the effect of wear is to increase the bearing bringing the teeth, eventually, to the nearest approach to the perfect involute shape that will allow proper lubrication. The final tooth form is practically (and providentially) stabilized by the fact that the high points must govern the contact and, since the zones around the pitch points are high, they carry the most pressure with the nearest approach to rolling contact, while the tips and roots of the teeth are only called upon to accept pressures that result in equalized wear under conditions involving more rubbing contact.

Refer to Fig. 45. The full line again represents a true involute curve, as in Fig. 44. The dotted line shows a tooth curve that has points outside the involute curve. Herringbone or helical teeth of this type will not function properly because contact is no longer governed by the pitch point A. When the high points at C and B make contact, the continuity of pitch line contact is destroyed with resulting irregularities in angular velocity that produce vibration and shock. Moreover, teeth of this character cannot be stabilized in form by service.

From the foregoing considerations, we can draw a few useful conclusions of a practical nature. First, in the straight spur gear, accurate involute tooth form is a fundamental necessity, no deviation either *above* or *below* the curve can be permitted if absolute uniformity of motion is desired. Invariable tooth form is very difficult to produce commercially and, in the case of the spur gear, it will be destroyed by wear. It must be conceded, of course, that the spur gear has considerable practical utility for many purposes within a limited field, but there are few applications where the herringbone gear does not offer decided advantages, while most of the modern examples of high-power high-speed gearing are entirely beyond the range of the spur type. Second, in the herringbone and helical gear, accurate involute tooth form is not a fundamental necessity provided the deviations are inside the involute curve through the pitch point (see Fig. 44). Teeth that satisfy this requirement are *not at all difficult* to produce commercially by the usual methods of *generation*. If, however, we hold too closely to the theoretical fetish of the pure involute tooth, our practical difficulties may increase out of all proportion to the advantages gained. A dulled edge or broken corner of a hob is liable to produce a tooth contour that lies outside the involute, in places, if our cutter is designed to produce an *exact* involute when in *perfect* condition.

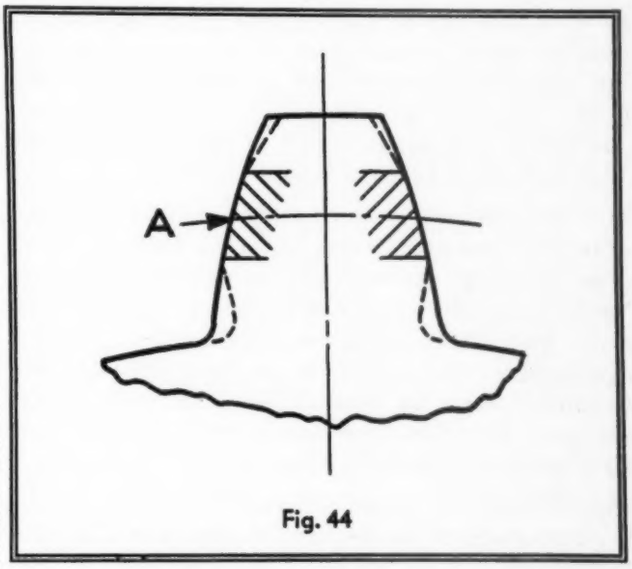

Fig. 44

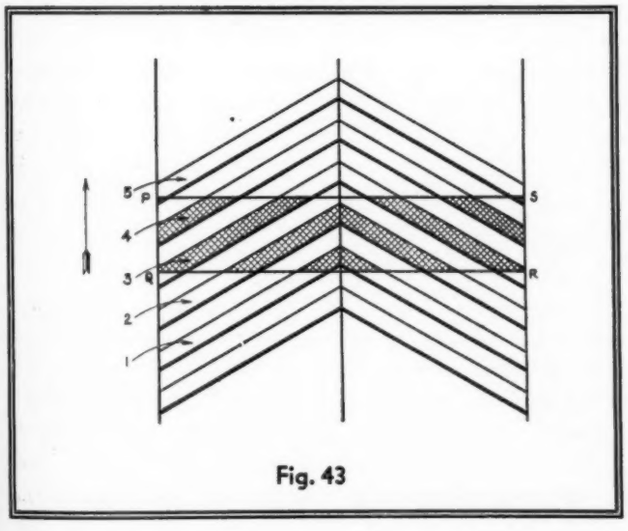

Fig. 43

Practical experience has demonstrated the desirability of generating the modified involute illustrated by the dotted line in Fig. 44. The maximum deviation is, of course, quite small, in most cases only a few thousandths, sufficient to insure that in the performance of actual gear cutting there shall be no part of the tooth contour *outside* the involute curve through the pitch point.

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Accuracy of Division. Theory assumes that the teeth of gears and pinions are uniform in thickness and evenly spaced around their respective pitch circles. In practice it has been necessary to spend much time and effort and vast sums of money in order to reach modern standards of perfection in this respect. Accuracy of division, more than anything else, determines the limit of angular velocity at which herringbone gears can be successfully operated. A few years ago it was considered inadvisable to operate spur gears at a peripheral velocity of more than 1500 ft. per min. or herringbone or spiral gears at more than 3000 ft. per minute. Today the limitation for spur gears, if made by usual commercial methods, remains about where it was, because the contour of the teeth enters so largely into the problem. But the herringbone gear, *which is not handicapped* by the tooth contour

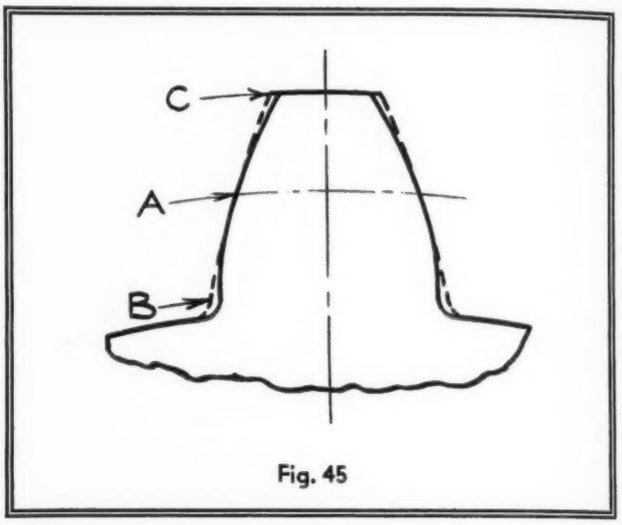

Fig. 45

limitation, has been developed to a point where it will operate smoothly and successfully at any velocity within the safe limit of centrifugal stress for the material of which it is built.

The Choice of Spiral Angle. There is a wide range of choice for the spiral angles of herringbone and helical gears, from zero (spur gears) to 45 degrees. Increase of spiral angle increases the axial and normal pressures on the teeth for the same tangential or useful driving pressure, while the normal thickness of tooth is reduced. On the other hand, for the same circumferential pitch, pressure angle and working depth of tooth, continuity of contact can be maintained within less total face width if the spiral angle is increased. It is usual to proportion the working depth to the normal instead of the circumferential pitch in order to maintain a uniform relationship between tooth height and tooth thickness. This largely offsets gain in continuity.

The spiral angle of commercial Wuest (hobbed) herringbone gears has always been about 23 deg., representing a fair average between extremes best suited for conditions where the available face width is not specially limited. This standard has endured for more than twenty years and has been widely copied. The face width of Wuest gears should not be less than six times the circular pitch, but the pitch of a herringbone

gear is always much less than the pitch of spur gears for the same service, so the proportions are normal. Some gears with continuous teeth are specially proportioned to meet conditions where it is necessary to reduce the face width to a minimum. The spiral angle varies from about 27 deg., for wide gears, to 33 deg. for narrow gears. This variation, for different widths, is incidental to the process of producing these gears, but it happens to meet practical requirements quite efficiently. A narrow gear should have a steeper spiral angle than a wide gear of the same pitch in order to insure continuity of engagement.

Certain high-speed turbine gears are cut with spiral angles of 45 or 30 degrees. For many years it was considered by most gear manufacturers that the 45-deg. gear was the quietest. This theory has not been verified by experience and the present tendency is to reduce the angle to 30 degrees. The best

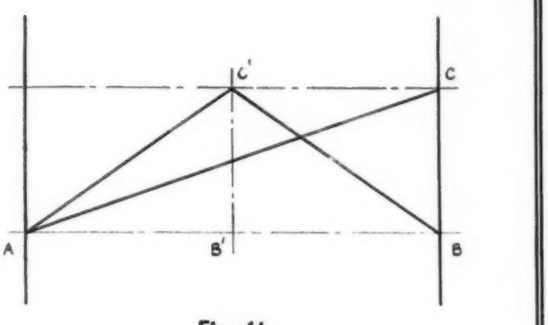

Fig. 46

general limits for the spiral angle of commercial herringbone gears lie between 20 and 35 degrees. Single helical gears of the same general proportions should have spiral angle of about half these values, to give the same continuity of engagement for equal pitch and face width.

Fig. 46 shows the developments of herringbone and single helical gears, superimposed. A-B is the face width, B-C, the overlap. The spiral angle B, A, C for a single helical gear is equivalent to B′, A, C′ for a herringbone gear of the same pitch. Single helical gears have the disadvantage of producing end thrust, which must be taken care of by the introduction of suitable thrust collars or bearings. Small spiral angles are desirable for this type of gear to reduce end thrust, but the angle must not be too small in relation to the face width and pitch or there will no longer be continuity of engagement which is the sole basis for the superiority of the helical to the spur gear. The shafts supporting single helical gears should always be provided with adequate thrust bearings.

Invariability of spiral angle is an *absolute necessity* for all types of helical gears. Some hobbing machines are specially designed with this end in view. The machines themselves differ widely in general design since they have to produce gears of many different types and sizes. But the fundamental gear that produces the spiral angles are the same in all machines and a gear produced on any machine today or fifteen years ago can be exactly duplicated at any time and on any other machine.

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All that has been said so far has to do chiefly with gear-cutting processes and machines, a necessary preface to what follows. The rest of this article deals with practical considerations which, it is hoped, may prove useful to mechanical engineers as a guide to the selection of gears.

Strength and Materials. The original gear teeth were made from cast iron or wood. While their primary purpose was to transmit power by rotary motion, the teeth were generally subjected to stresses that bore no relation to the useful power transmitted but were caused by shock and vibration incidental to their own imperfections supplemented by inaccurate and unstable alignment.

For heavy-duty service steel gears will carry the same loads with such reduced dimensions that they are actually less expensive than cast iron, besides being far more reliable.

The usual "practical" text-book harps on the "strength" of gear teeth and gives sharply diminishing factors with increasing velocity. This was perfectly logical for the selection of spur gears, mostly cast iron, with imperfectly cut teeth. But the modern precision herringbone gear has entirely different limitations.

The greater the precision the smaller the deduction to be made for increased speed.

Strength is *not* a factor in the design of steel herringbone gears for any ordinary purpose. Surface pressure between the teeth is the limiting factor, and even this is largely controlled by the efficiency, or otherwise, of lubrication. A pair of steel gears with sufficient tooth surface to prevent rapid wear from surface abrasion will always be several times stronger than necessary, to insure absolute safety against the breakage of teeth. If gears and shafts are properly proportioned to the usual accepted standards for any purpose, an unexpected shock will break the shafts first.

Materials are chosen for resistance to surface abrasion.

Precision herringbone gears should *not* be hardened after cutting. There is one exception to this rule. Small gears such as are used for automobile and truck transmissions may be hardened successfully because they operate at relatively low speeds and the limitation of dimensions is more important than extreme precision.

For medium and large-sized gears it is usually best to rely on high-carbon or heat-treated alloy-steel forgings for small pinions and steel castings for large pinions and gears.

Remember that the object of using herringbone gears is to eliminate shock, noise and vibration, and in order to obtain the desired results the gears have to be made with extraordinary precision. Modern methods with their background of years of patient and costly development have made it possible to produce such gears commercially at very low cost. Put the finished product through any heat-treating process and the result is a distorted caricature of the original gear.

For ordinary purposes, where space is not the prime consideration, the pinions are usually made from forgings of 50 per cent to 60 per cent carbon steel. The gears used with these pinions are made from acid open-hearth steel castings of standard grade.

For extra-heavy duty and for conditions where it is desirable to reduce dimensions to the minimum, harder materials are used.

The generated gear with continuous teeth is invaluable where considerations of design call for relatively narrow face width, because all the face is active. This is the only advantage over the hobbed gear beyond a certain neatness of appearance. The extra "strength" of the teeth is of no importance because it is not a factor in the design of herringbone gears.

Heavy-duty gears should be lubricated with semi-fluid lubricants. The tooth should allow no escape of such lubricants at the center, insuring even distribution.

Pitch Diameters, "Enlarged" Pinions, Etc. The drawing of a gear or pinion is usually embellished with three concentric circles, beginning from the outside marked O. D. (outside diameter), P. C. D. (pitch circle diameter) and R. D. (root diameter), respectively. If no mistakes have been made by the draftsman, O. D. and R. D. are correctly represented by the dimensions given them. But this is not necessarily true for the dimensions given for the pitch circle diameter (P. C. D.).

Generated pinions may be "enlarged" and their engaging gears "contracted" for perfectly good and practical reasons, which will be explained later, but the pitch circle diameters will not change because each can have only *one* value for a pair of gears with fixed velocity ratio and fixed shaft centers.

Let us assume that the number of teeth in our pinion is n and the number of teeth in our gear is N and that the distance between shaft centers is C inches.

Then the velocity ratio is N/n.

The sum of the pitch diameter is 2C.

The true pitch diameter of the *pinion* is $2Cn/(N+n)$

The *true* pitch diameter of the *gear* is $2CN/(N+n)$

These values are basic and unalterable. We can enlarge and contract, changing our O.D.'s and R.D.'s as we please, but we cannot alter the true P.C.D.'s.

But convenience, habit and long association with gears that are neither enlarged or contracted have formed the impression that the pitch-circle diameter is situated at a definite radial distance (called the addendum) inside the "O.D." and at another definite radial distance (called the dedendum) outside the "R.D."

Furthermore, the gear cutter has acquired the habit of setting his gear tooth calipers to a fixed depth corresponding to the *standard* addendum for the pitch of the tooth to be cut and should not be discouraged by the introduction of unnecessary variables.

So the old circle is drawn and marked (P.C.D.), but it should be remembered that the figure given is not, necessarily, the *true pitch diameter* but may be merely the diameter of a concentric circle located at a fixed distance within the outside diameter.

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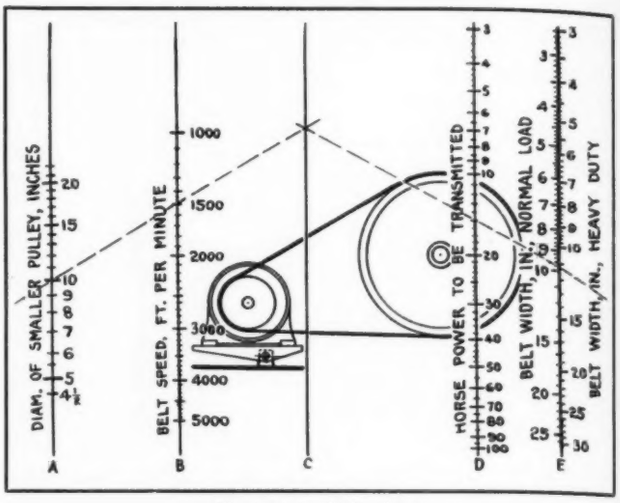
Chart for Modern Short-Center Belt Drives

By W. F. SCHAPHORST
Mechanical Engineer

HERE is something new—a chart for modern short-center drives. It is based on the fact, discovered by research, that the diameter of the smaller pulley has much to do with the belt width required to transmit a given horsepower. Thus in the old days we used the rule, "A belt one inch wide will transmit one hp. for each 800-ft.-per-min. belt velocity." Such a rule is inapplicable to modern short-center drives, as a study of this chart will indicate.

To use the chart, run a straight line through the diameter of the smaller pulley, column A, and the belt speed in ft. per min., column B, and locate the intersection in column C. Then from that point of intersection run a second straight line through the horsepower to be transmitted, column D. The intersection with column E then gives the proper belt width to use.

For example, the two dotted lines drawn across the chart show that where the smaller pulley has a diameter of ten inches, the belt speed being 1500 ft. per min., and 15 hp. are to be transmitted, a belt ten inches wide will be required if the load is normal. Column E also shows that if it is a heavy-duty load the belt should be a little more than 11 inches wide. In other words, column E gives dimensions for both normal loads and heavy-duty loads.



Short-center belt chart

This chart is safe for all practicable short-center drives and for all pulley ratios up to six to one; belts being two-ply and of high quality. For longer center distances the results are even safer; which means, of course, that this chart may be safely applied to all center distances that have the approval of up-to-date practice.

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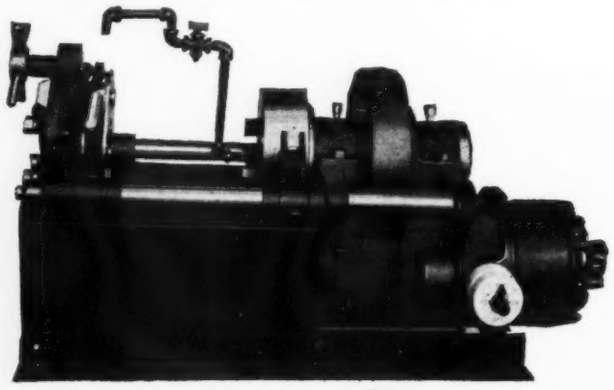

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Edited by BARNEY HORRIGAN

Professor (in the middle of a joke): Have I ever told the class this one before?

Class (in a chorus): Yes.

Professor (proceeding): Good! You will probably understand it this time.

* * *

Dear Mr. Palmolive: I bought a tube of your shaving cream. It says no mug required. What shall I shave?

Yours truly, OSWALD MCMANN.

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Housewife (running out to the street): Have you the time?

Iceman: Yes, madam, but we'll have to get someone to hold my horses!

* * *

A professor coming to one of his classes late, found a most uncomplimentary sketch of himself drawn on the board. Turning to the nearest student, he demanded angrily, "Do you know who is responsible for this atrocity?"

"No, sir, I don't," replied the student, "but I strongly suspect his parents."

* * *

Salesman: Do you wear a nightgown or pajamas?

Young Lady: No.

Salesman: My name is Thomas—Joe Thomas.

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Advertisement: You get the girl, we'll do the rest.

Youthful Groom: That's hardly fair.

* * *

She: Why do they call ships, "she"?

He: Oh, I guess because they make their best showing in the wind.

* * *

"Yassah," said the darkey, "Ise named fum my parents. Daddy's name was Ferdinand and Mammy's name was Liza."

"What's your name then?" asked Sambo.

"Ferdiliza."

* * *

"How about a little kiss, girlie?"

"No, I have scruples."

"Well, that's all right, I've been vaccinated."

* * *

Mabel: Why did Bess quit her job in the Lost and Found Department?

Frances: Oh, she had to take too much stuff that was uncalled for.

* * *

Gal: So your new friend works at the Purple Goose Night Club; what does he do?

Flapper: He didn't say, but from the way he performed last night, I guess he must be a bouncer.

* * *

Professor of Chemistry: What combination dissolves gold the quickest?

Student: The marriage combination.

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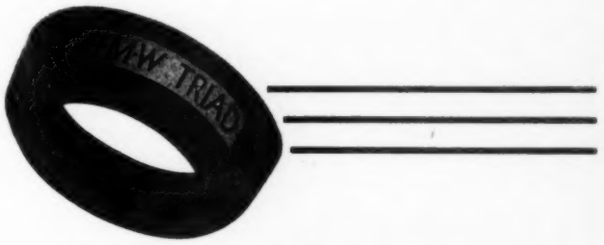

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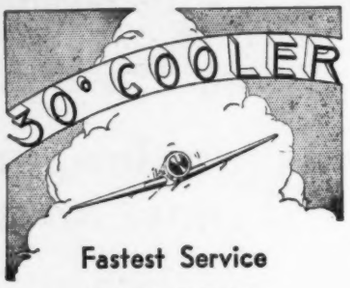

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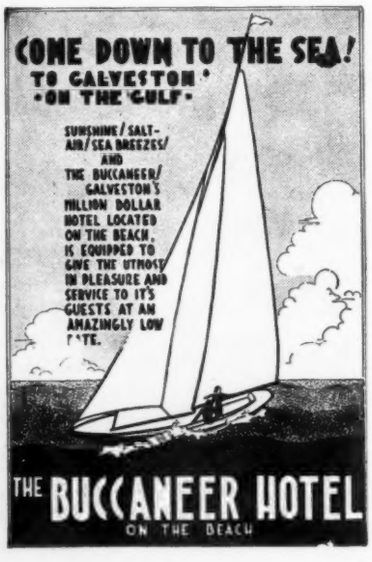
COME DOWN TO THE SEA!
TO GALVESTON
ON THE GULF
SUNSHINE / SALT-AIR / SEA BREEZES / AND THE BUCCANEER / GALVESTON'S MILLION DOLLAR HOTEL LOCATED ON THE BEACH, IS EQUIPPED TO GIVE THE UTMOST IN PLEASURE AND SERVICE TO ITS GUESTS AT AN AMAZINGLY LOW RATE.
THE BUCCANEER HOTEL
ON THE BEACH

Tretolite Suit Alleges Infringement

Tretolite Company, Dallas, Texas, has filed action in equity in the courts at Tulsa, Okla., naming Burke-Greis Oil Company as defendant and alleging infringement of the plaintiff's oil treating patent No. 1,467,831.

Two other suits, naming infringements of the above and related patents are on file in Southern California, one naming Dehydrators, Ltd., Italo Petroleum Corporation of America, and the receiver for the latter as defendants, and the other naming All-American Chemical Products Company and C. W. Camp.

Pipe Line Contractors Organize

The Associated Pipe Line Contractors of America is the name of an association organized by pipe line construction companies to formulate a code of fair competition to effectuate the purpose and policy of the National Industrial Recovery Act. Offices of the association have been established at 425 Exchange Bank Building, Tulsa, Okla.

Directors of the association are S. M. Williams, Jr., Williams Brothers, Inc.; John B. Sheehan, Sheehan Pipe Line Construction Company; J. J. Connor, Connor & Son Construction Company; O. E. Dempsey, Kelly Dempsey & Company; C. B. Stewart, Mitchell-Stewart Construction Company, and J. C. Truman, Truman-Smith Construction Company.

S. M. Williams, Jr., is president and John B. Sheehan, vice-president. G. E. Matt is secretary.

In transmitting a code to the President, the Association expressed a request that this code be approved, accepted and designated as the basic code governing the activities and operations of pipe line contractors; also, that this code be used as the basis of rates of pay and hours of employment in connection with pipe line construction projects.

Henry C. Morris Dies

Henry C. Morris, president and general manager of the Dallas Gas Company, Dallas, Texas, died August 17, after a two weeks' illness.

A native of Michigan, Mr. Morris began his business career in a gas meter repair shop in Detroit, becoming superintendent of construction for the Saginaw Gas Company in 1902. In 1905, he was made assistant general manager of the Bay City Gas Company. He came to Dallas four years later as superintendent of construction and operations for the Dallas Gas Company. From this position he rose to the presidency of the company.

Mr. Morris was a director of the American Gas Association and former chairman of the natural gas department of the Association. He was also vice-chairman of the national directing committee of executives of the American Gas Association.

Dardelet Licenses General Electric

The General Electric Company, Schenectady, New York, and all its subsidiary companies in the United States have been licensed by the Dardelet Threadlock Corporation to manufacture for their own use bolts, nuts, and other threaded parts threaded with the Dardelet Self-Locking Screw Thread.

A.I.M.E. Meetings in October

The Petroleum Division of the American Institute of Mining and Metallurgical Engineers will hold its Mid-Continent fall meeting on October 6 and 7 at Dallas with headquarters at the Baker Hotel, and the California Section will meet at Los Angeles in the assembly room of the California Oil and Gas Association, on September 29.

These meetings will be of special importance to engineers and research workers who are connected with the oil industry, since several papers will be presented by noted specialists in their particular fields.

Professor W. K. Lewis, Head of the Department of Chemical Engineering at Massachusetts Institute of Technology, will discuss the subject "Physical-Chemical Relationships of Hydrocarbon Gas-Liquid Mixtures at High Pressures". The development of oil and gas in deep horizons where pressures far in excess of critical values are encountered, has made it imperative that engineers possess a comprehensive knowledge of the behavior of gases and liquids under high pressures.

Another fundamental paper by M. Muskat and R. D. Wycoff of the Gulf Research and Development Corporation is entitled, "A Theoretical Analysis of Water Flooding Net Works". This paper is a comprehensive analysis of reservoir conditions wherever water drive is present.

George L. Nye of the Tidewater Oil Company will discuss "Recent Changes in Reservoir Pressure Conditions in the East Texas Field." Several other papers of importance are also scheduled and it is planned to devote one session to a discussion of the problems associated with estimation of natural gas reserves.

At the California meeting the following papers will be presented: "Vertical Flow of Oil and Gas Mixtures" by J. E. Gosline of the University of California; "Water Drive Problems" by Victor Wilhelm of The Texas Company; and "Middle Dome of Kettleman Hills" by Joseph Jensen of the Associated Oil Company.

Erie Bolt & Nut Company Appoints Moorlane Company Distributors

The Erie Bolt & Nut Company, Erie, Pa., has opened distributing centers in Tulsa, Okla., and Houston, Texas, the Moorlane Company having been appointed distributors of its products. In both places the Moorlane Company is carrying a complete line of bolting equipment for the oil fields and refineries.

Struthers-Wells Appoint Representatives

Struthers-Wells Company, Warren, Pa., manufacturers of chemical process equipment, recently announced the appointment of the Kerr Machinery Corporation, Kerr Building, Detroit, Mich., as their exclusive representative in the state of Michigan, exclusive of the northern peninsula; and also named the National Equipment Company of Salt Lake City, Utah, as their representatives in the states of Utah, Nevada, Idaho, Montana and Wyoming, west of Rock Springs.

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New Drilling Depth Record for Texas

THE deepest oil well ever drilled within the State of Texas and which may become the sixth test in the world to exceed a depth of 10,000 ft., is the Yount-Lee Oil Company's Boyt 1, in Liberty County, Gulf Coast district.

The attainment of this depth, while an important achievement in the annals of oil well drilling history, is not the most significant development in connection with the test, rather the efficient manner and apparent ease with which the hole was carried to its present depth of 9863 ft. are the outstanding features. For instance, a total of 9100 ft. of hole was drilled in 60 days after spudding, an average of 151⅔ ft. per day. The well was spudded April 6, 1933, and the hole has been cored at every break of the formation, more than 100 cores having been taken. Despite the encountering of heaving shale, the graveyard of many Gulf Coast tests, at 7500 ft., the well had 7792 ft. of open hole when 9197 ft. of 7⅝-in casing was landed. The last 1700 ft. of this distance penetrated a continuous body of heaving shale.

Strict control exercised over drilling conditions and care of equipment lend significance to test.

By WARREN L. BAKER

The successful control of this shale formation is a noteworthy accomplishment and is to be attributed largely to scientific chemical treatment of the drilling fluid. Baroid, Aguagel and Opalite were mixed at the slush pit with special chemicals selected by the company after extensive laboratory study. Three types of shale were identified and it was necessary that the drilling fluid be provided with characteristics suitable for combating all three at once. By testing at the well from three to five times daily, a suitable drilling fluid was maintained constantly, the weight of which ranged from 10¼ lb. to 16½ lb. per gal., depending upon conditions. When the weight of the rotary mud was increased to 16½ lb. per gal. it had a specific gravity of 1.95 and a weight of 121½ lb. per cu. foot.

The many valuable functions performed by rotary drilling fluids in connection with oil well drilling operations become more important as holes increase in depths. The deeper the hole the more difficult and more important it becomes to have a mud capable of satisfactorily performing its duties. In the case of the Yount-Lee Boyt 1, this was particularly true because of the heaving shale formations. The formation has for many years provided a most complex drilling problem, often caving in above the drilling bit so compactly that it is impossible to extract the bit from the hole, or, when the drill pipe string is withdrawn, the hole often fills up to such an extent that it is impossible again to get on bottom. Extensive study during the past few years of this important problem has indicated that when the formation comes in contact with fluid it apparently assumes a swelling action that increases its caving characteristics. Therefore, it was necessary in the Boyt test that the mud be sticky enough to form quickly an adhesive, sealing film on the walls of the hole and, at the same time, retain a live, fluid nature capable of holding the cuttings in suspension long enough to permit their removal from the deep hole. Because of the accurate control maintained over the consistency of the drilling fluid no trouble has been experienced in circulating cuttings from the hole, and this work has also been the principal factor in permitting penetration through the cavey shale formations without difficulties.

When 9197 ft. of 7⅝-in. casing was landed in the well it set a new record for the Gulf Coast district. Despite the fact that when it was decided to set casing at 9200 ft. the hole tested clean and open, casing stuck at 7600 ft., necessitating the pulling of the string and laying it down in singles. After reaming, the full 9197 ft. string was landed. The loss of circulation at 9000 ft., and the heaving shale hazards caused the operators to abandon the practice of cementing the casing string. Many Gulf Coast wells have set casing without cementing and no concern is felt over the failure to cement this long string. The lower section of the casing string consisted of 4397 ft. of 26.75-lb. Jones & Laughlin casing. The upper section of 4800 ft. was special-made upset National Tube casing, having a weight of 26.75 pounds. At 1405 ft., 10-in. surface casing string is the only other pipe in the hole. Prior to running the long string of casing the hole was carefully prepared and a special mud was mixed so as to prevent caving of the heaving shale in the hole.

In no respect is the rig that drilled Boyt 1 different from many others that have made holes to much shallower depths. In fact, its equipment is much smaller than many rigs used in the Oklahoma City field and in some of the deep fields of California.

Extra precautions, however, have been taken to insure proper working condition of the equipment. The rig is the same one used by the Yount-Lee Company in drilling its No. 1 Plummer in the same district to 9334 feet. Proper care of equipment so as to obtain the greatest efficiency in drilling equipment and careful control of drilling operations are two practices that have enabled the Yount-Lee Oil Company to make this remarkable record and thereby lend real significance to the achievement.

New York Offices of General Electric Moved

The General Electric Company and four of its associated companies have announced the removal of their offices in New York City to the new General Electric Building, 570 Lexington Avenue at 51st Street. Included are the executive offices, New York district office, air conditioning department, electric refrigeration department, Atlantic division of the incandescent lamp department, merchandise department, and plastics department of the General Electric Company, and the General Electric Contracts Corporation, G. E. Employees Securities Corporation, General Electric Realty Corporation, and International General Electric Company, Inc.

New York City headquarters were formerly at 120 Broadway, where for 15 years three complete floors were occupied. Approximately 50 per cent of the new building is occupied by the company.

Fourteen of the General Electric offices in the new building have been equipped with air conditioning equipment. In all of them the new type of quietly operating fans are standard, and all have the most modern lighting fixtures. The latest wiring devices, including G-E underfloor duct, facilitate arranging and rearranging office fixtures to suit changing requirements; it is an easy matter to install floor outlets wherever and whenever desired. In connection with the club rooms of the women employes of the company there is a complete G-E equipped kitchen.

Smith Separator Appointed Fisher Governor Distributor

Fisher Governor Company, Marshalltown, Iowa, manufacturers of automatic control specialties, has announced the appointment of Smith Separator Company, Box 2003, Tulsa, Okla., as sales representative handling Fisher equipment throughout the State of Oklahoma and northern Texas.

Smith Separator Company is one of the oldest equipment companies, manufacturing and selling the well-known Smith oil and gas separator. This organization has had many years experience in the sale and service of Fisher controls and is in an excellent position to service the users of Fisher equipment.

In addition to several sales engineers in the regular Smith organization, C. D. Peterson, a graduate engineer, who has had nine years experience in the design, operation, and service of automatic controls at the Fisher factory, will be permanently located in Tulsa, to offer service in a technical manner.

Baroid Opens Houston Branch

The Baroid Sales Company of Los Angeles, Calif., exclusive distributors of Baroid, Aquagel, Lemco Mud Screens, Stabilite and other products for use in connection with oil well drilling fluids, has just opened a branch office at 1511 Second National Bank Building, Houston, Texas. The telephone number is Capitol 1642.

This office has been established in order to enable them to give more prompt and efficient service to companies operating on the Gulf Coast.

The office will be in charge of B. A. Pacific and will be the headquarters of J. W. O'Brien, Geo. H. Parsons and F. E. Palmer, sales engineers for the Gulf Coast district. Geo. L. Ratcliffe, general manager of the company, will make this office his headquarters about two weeks out of each month.

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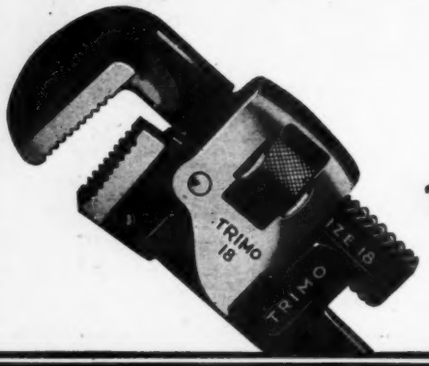
That's what your good money must secure if you want full value in a pipe wrench. No finer, stronger, safer wrench can be found than all-steel Trimo.



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Send for Circular or Catalog.

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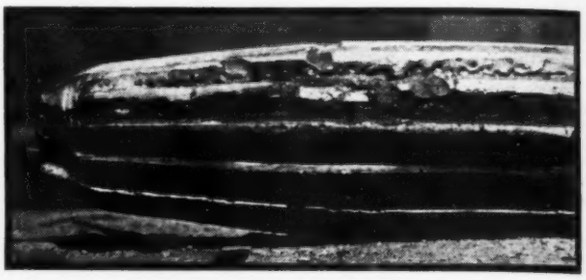
A Difficult Side-Tracking Job

ONE of the difficult problems that occasionally face oil well operators is that resulting from the loss of a "fish" or string of tools in a hole that has been cased. When this occurs, it becomes necessary to "side-track." Such a situation recently confronted a California oil company and after a week's unsuccessful effort to side-track, the job was finally accomplished by applying the best available materials and technique.

After failing to go through the casing with four mills, this company decided to try milling cutters that had been



View showing excellent condition of hard-surfaced mill after severe usage

hard-faced with a substance capable of withstanding the excessive temperature, the cause of previous failures. All oxide, scale and other foreign substances were removed from the cutters before applying a coating of Haynes Stellite. Three mills of graduated sizes, 5⅝-in., 7⅝-in. and 10¾-in., were specified for cutting the 11¾-in. casing. The 5⅝-in. mill was run first and went through the side of the casing in one shift; the second and third mills were run for the purpose of enlarging the hole to the desired size. In addition to going successfully through the casing, the 5⅝-in. mill made 12 ft. of hole.

The accompanying illustration shows the 5⅝-in. side-tracking mill. Its excellent condition is clearly seen and, in fact, it could make another run if necessary, without re-servicing. The small amount of wear on the starting end and almost negligible chippage of the hard-facing material are at once apparent.

The superior service provided by the use of hard-faced oil drilling tools is readily explainable, and is a direct result of its "red-hardness," or ability to retain its hardness up to a red heat.

Jensen Jacks Stocked by Bridgeport Machine Company

Jensen Brothers Manufacturing Company, Coffeyville, Kan., has appointed the Bridgeport Machine Company, Wichita, Kan., as distributors for Jensen jacks and power units. Bridgeport will carry the complete Jensen line in all field stores.

Extra Safety PLUS Long Life

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The statements we make concerning Hughes Valves are not mere "sales" claims —nor are they guess work. Detailed records of performance for the largest users of Valves are ACTUAL PROOF of safety, long life and "unbroken" service.

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Hughes Valves have already been TESTED for the job they are sent out on before they leave the plant. They MEASURE UP and also have sufficient RESERVE FOR SAFETY or they would not be "put to the task."

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85 PATENTS cover the Tretolite processes for conditioning crude oil to pipe line requirements and protect you against imitations and substitutions . . . Tretolite is the pioneer and developer of the processes universally used throughout the oil fields of the world.

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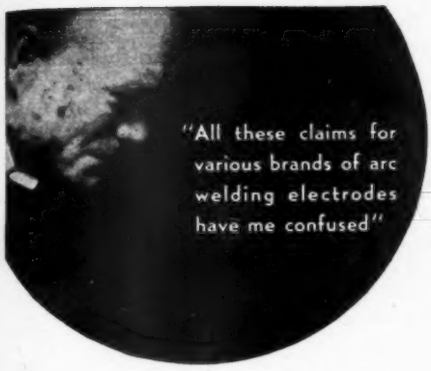
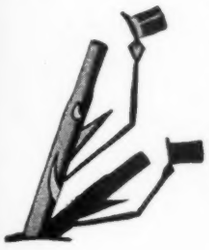


"I am 'FLEETWELD'... a shielded arc electrode that welds 2 to 3 times faster than bare or washed rods. I deliver a weld tensile strength of 65,000 to 80,000 lbs. per sq. in. ... Ductility of 20% to 30% elongation in 2"... Resistance to corrosion greater than mild rolled steel ... Resistance to shock and fatigue equal to that of mild rolled steel. Thousands use me because I produce highest quality welds at low cost. Try me!...the name is '*Fleetweld*'."

"I am 'ALUMINWELD'... how could you guess I work on aluminum ... castings, sheets and rolled shapes. I should be high-hat, because the high quality of my work makes me exclusive ... puts me in a class by myself. My welds look smart, no discoloration when polished, but really they're very dense ... that's why smart men order '*Aluminweld*'."

"I am 'MANGANWELD'... as my name implies I am used to weld manganese steel ... build up worn parts ... and all kinds of similar jobs. I operate in a shielded arc... produce a flat bead with no surface checks... My welds are solid ..They're tough..They're hard..and get harder when cold worked... Resist wear as well as heat treated cast manganese steel. Give me a chance to prove my statements... ask for '*Manganweld*'."

"I am 'HARDWELD'... when hard, tough, shock and abrasion-resisting surfaces are wanted they call for me to build 'em up. On rail or similar steel my welds are h-a-r-d... Hardness increases on cold working or quenching, yet my welds do not spall or check ... I make a flat bead which cuts grinding costs. Remember ... the name's '*Hardweld*'."



"I am 'STAINWELD A'... 18-8 stainless steel is my meat. Grind my welds, then polish, then try to find 'em ... that's how close they are in all respects to the base metal ... strength, ductility and corrosion-resistant qualities are virtually the same. For 18-8 stainless, order me ... '*Stainweld A*'."

"I am 'LIGHTWELD'... sheet work is my specialty, 18 ga. to 24 ga. In weld appearance I'm a smoothie. Being faster than fast, I'm easy to work with and don't burn through. Some call me 'Mac' cause my welds are so tight, but when you order ask for '*Lightweld*'."

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W 38

The Petroleum Engineer, issued thirteen times a year by the Petroleum Engineer Publishing Co., 405-409 Tower Petroleum Bldg., Dallas, Texas. Subscription price, $1.00 per year, except in Canada, where the price is $1.65 per year—15 cents a copy. Entered as second-class mail matter May 1, 1932, at the post office at Dallas, Texas, under the Act of March 3, 1879.

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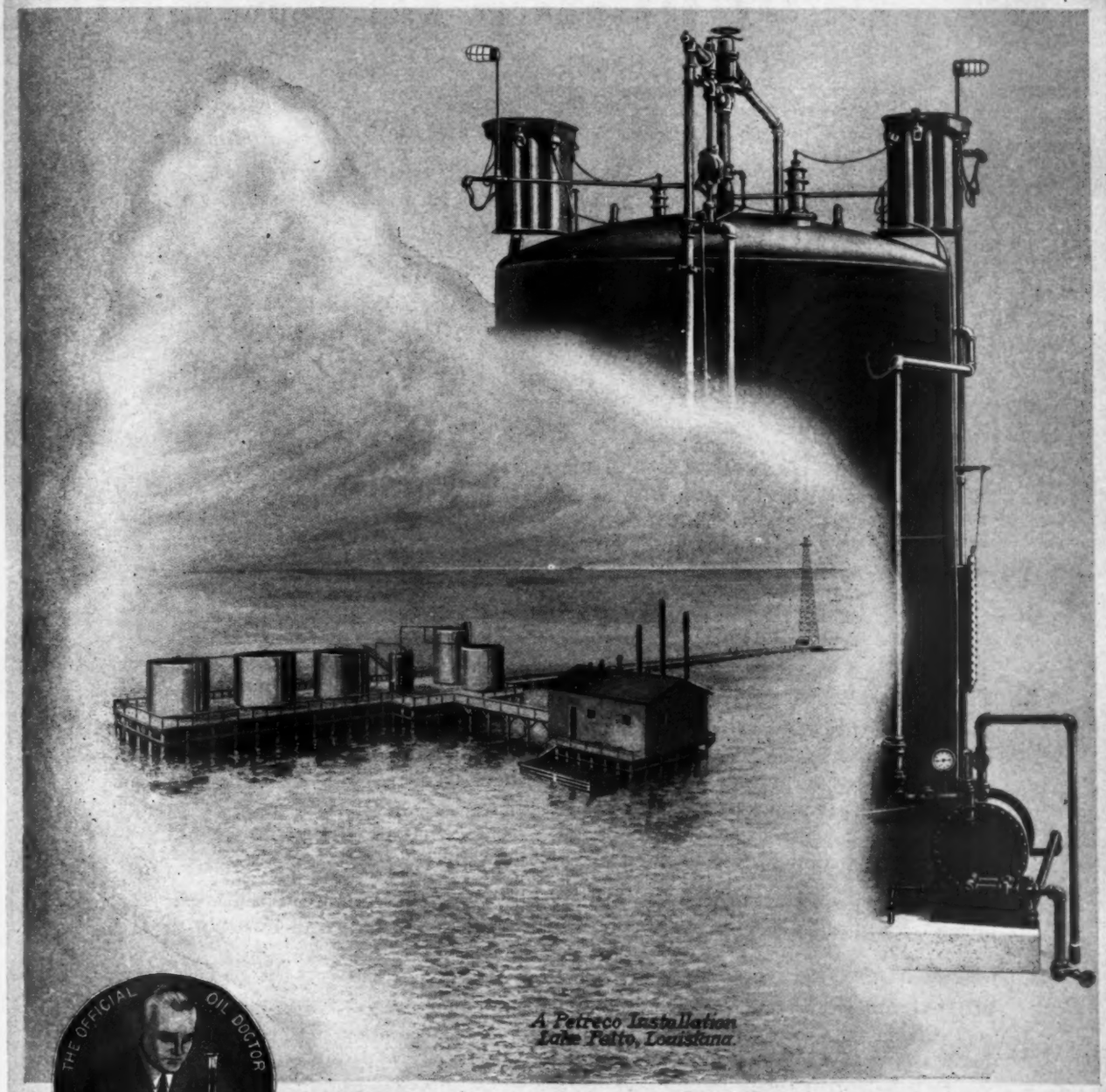

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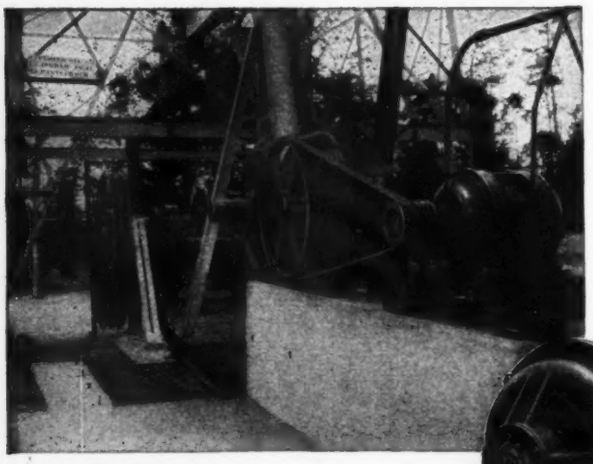
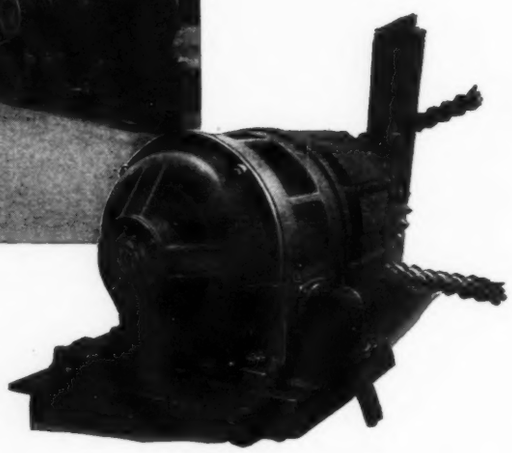
Two G-E Motors for new economies in pumping



A G-E triple-rated Y-Delta induction motor driving an oil-well pumping rig in the East Texas field



G-E gear-motor operating an oil-well pumping rig in a Gulf Coast oil field, Texas

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Oil men find that the most economical method of well pumping, under present regulations, is to use a motor of low horsepower rating in order to keep electric power and costs at the minimum. That's why they select G-E triple-rated Y-Delta motors, which provide high efficiency and good power-factor at three horsepower ratings—a low rating for present production, a medium rating for an increased allowable, and a high rating for full production or for pulling rods and tubing.

These motors, which cost little more than ordinary single-rated motors, will lower your pumping costs and will take care of your future as well as present requirements.

2. GEAR-MOTORS

You can obtain new economies in slow-motion pumping by using G-E gear-motors because they combine the economies of high-speed motors and accurately cut helical gears that run in a bath of oil. Gear-motors are efficient. They deliver the full-rated motor horsepower at the output shaft. They reduce installation expense, too, because they are so compact and easy to install.

Additional information on these dependable motors can be obtained at the nearest G-E office, or from General Electric, Schenectady, New York.

200-695H

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TOGETHER

To Serve the Oil Industry

The Continental Supply Co., *And* Broderick & Bascom Rope Co.

The Continental Supply Co. is now the distributor of Broderick & Bascom Oil Country Ropes in the Mid-Continent and certain other fields.

The Continental is one of the largest distributors of oil country supplies in the world. Its stores are to be found in every active Mid-Continent field, and in Montana, Wyoming, Colorado, New Mexico, Illinois and Kentucky — with adequate supplies of B & B ropes at all stores.

The Broderick & Bascom Rope Co. has the valuable experience of fifty-eight years making nothing but wire rope — high grade wire rope! This company was among the first to introduce wire lines to replace manila in the rapidly developing oil fields of years ago. During this long period B & B ropes have maintained an unexcelled reputation for long life — for economy — for general, all 'round satisfaction.

Now, with Continental and Broderick & Bascom joining hands, you have at your beck and call the best the world has to offer in oil field supply service — and in wire rope.

The Continental and Broderick & Bascom are most anxious to please — and the rope you get is sure to please.

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OIL COMPANIES are now selling Ethyl Gasoline at only 2¢ a gallon over the price of regular gasoline.

To the average car owner this means an added expenditure of only about sixteen cents a week to buy Ethyl instead of regular gasoline. *And this statement overlooks the proved economies of Ethyl and of high compression engines designed for Ethyl!*

What is the reward—to car manufacturer and car owner—offered for this 16¢ a week investment? Improvements from the higher compression ratios permissible with Ethyl Gasoline include:

(*1.*) ***More power and speed***—The increased fuel efficiency of higher compression results directly in greater horsepower throughout the engine speed range, with no increase in fuel consumption.

(*2.*) ***Faster acceleration***—This gain in horsepower with no increase in car weight results in substantially improved accelerating ability.

(*3.*) ***Better hill-climbing ability***—The gain in power permits greater speed in climbing any given hill and often results in gaining the summit of the hill without shifting to the lower gear necessary if the car were of lower compression ratio.

(*4.*) ***Less heat to cooling water***—Increased fuel efficiency offers needed relief to cooling systems, instead of a further increase in load from the more powerful engine of 1934 models.

(*5.*) ***Cooler exhaust gases***—The exhaust gases of a high compression engine are cooler at any given r.p.m. than are those of the same engine with a lower compression ratio.

(*6.*) ***Lower extreme bearing loads***—At those speeds which produce bearing strains, (high speeds) the forces of inertia greatly exceed the opposing forces of gas pressure. The *increased* gas pressures of higher compression engines therefore more nearly balance the forces of inertia than do smaller gas pressures. In this manner, higher compression actually *lowers* extreme bearing pressures.

* * * *

MANY manufacturers will take advan-

And remember:

THE AVERAGE CAR OWNER USES ONLY ABOUT 8 GALLONS OF MOTOR FUEL A WEEK

tage of the recent improvement in the anti-knock value of regular-priced gasoline to get these high compression rewards to some extent.

But a car designed to the limits of regular-priced gasoline will still, of course, fall short of the competitive superiority of a similar car designed to take full advantage of Ethyl Gasoline.

In building your 1934 car, therefore, you may either increase compression to the permissible limit of present day regular-priced fuel—thus maintaining competitive performance comparison with other cars designed for regular gasoline—or take advantage of Ethyl Gasoline, at a premium of only 2¢ a gallon, to make a greater compression increase and give your car truly outstanding performance.

In addition to permitting performance improvements through increased compression, Ethyl Gasoline insures easy starting, freedom from vapor lock, and safe minimums for gum and sulphur contents. When it is recommended that cars be run on Ethyl Gasoline, car owners are automatically discouraged from using the *lowest price* gasoline and instead are encouraged to use a fuel that is satisfactory in *every* respect, thus insuring continued satisfaction from their cars.

Wherever—and by whatever oil company—it is sold, Ethyl Gasoline is required to meet definite specifications for every needed quality of motor fuel. It is doubly tested before and after Ethyl fluid is added, for anti-knock quality, distillation characteristics, gum, and sulphur contents. After it is placed in retail pumps for sale to the public, inspectors gather samples for retesting to make sure that Ethyl users always get full quality.

Design your 1934 cars for Ethyl Gasoline and thereby get the competitive superiority you want. Recommend that Ethyl always be used and thereby aid every customer to get constant, maximum satisfaction from the car he buys.

Engineers of the Ethyl Gasoline Corporation will be glad to cooperate with you in getting maximum benefit from compression increases. Ethyl Gasoline Corporation, New York City.

Smoother Running for the casing crew

Greater Security for the operator!

REASONS!

NATIONAL A.P.I. DIAMOND BX AND B8 CASING

NATIONAL SEAMLESS A. P. I. CASING, DRILL PIPE, TUBING, LINE PIPE, AND COUPLINGS.

1. Seamless—no welds.
2. Higher tensile strength.
3. Greater resistance to collapse.
4. More accurately threaded joints.
5. Unusual ductility.
6. Exceptional uniformity.
7. Maximum dependability.
8. Greater recovery value.

NATIONAL Seamless Casing has been tried and tested under every known service condition with the unqualified approval of operators and casing crews. Successfully run in a greater number of deep wells than any other casing, consistently meeting every challenge that stubborn holes could offer. Smoother running and greater security have made NATIONAL Seamless—

America's Preferred Casing

NATIONAL TUBE COMPANY, Pittsburgh, Pa.

Visit the exhibits of the Subsidiary Manufacturing Companies of United States Steel Corporation, in the GENERAL EXHIBITS BUILDING — A CENTURY OF PROGRESS EXPOSITION, *Chicago.*

NATIONAL SEAMLESS

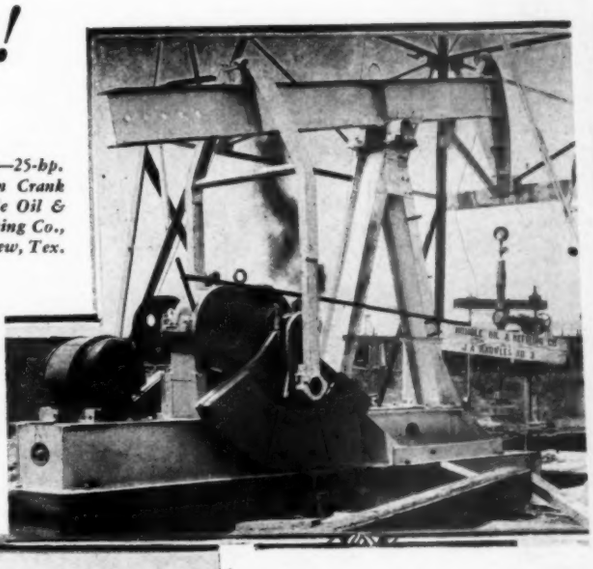
PIERCED FROM SOLID BILLETS - NO WELDS

wherever oil is produced

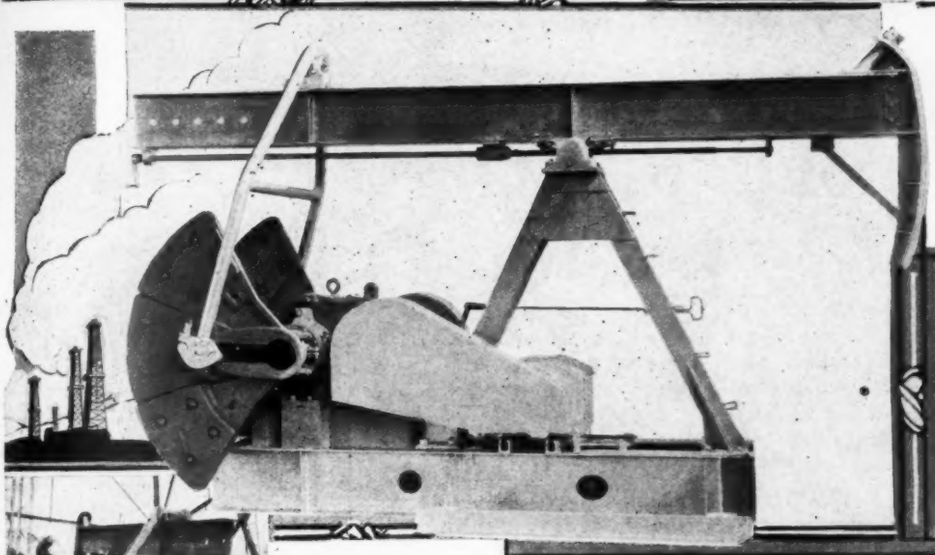
"IDECO" geared pumping units are used . . . . . .

A type for every service!

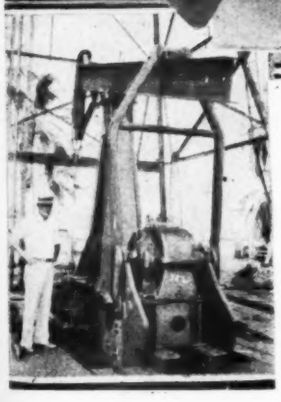
HM-67 Unit—100-hp.—Henderson, Tex. Equipped with back side crank for multi-well pumping.



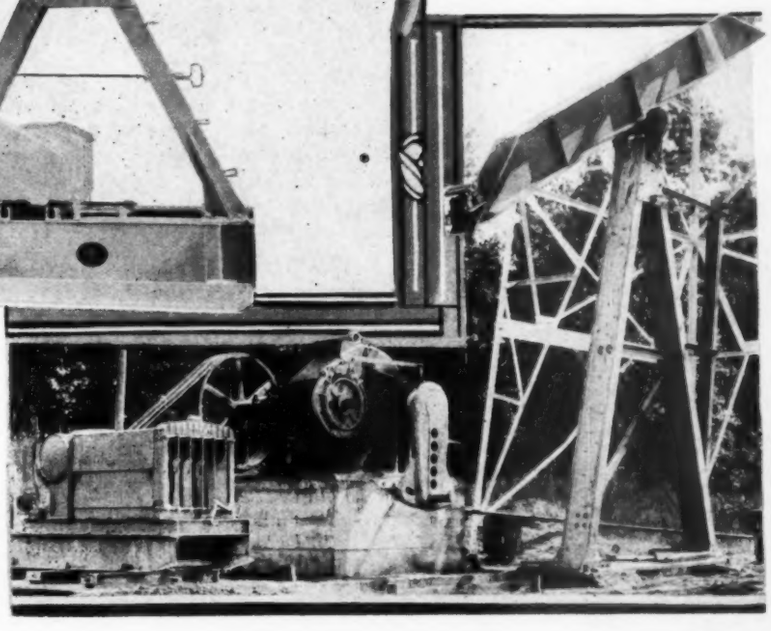
A-3 Unit—25-hp.—Twin Crank Humble Oil & Refining Co., Longview, Tex.



A-3 Unit—25-hp.—Twin Crank Standard Oil Company of New Jersey, Venezuela, S.A.



A-3 Unit—25-hp.—Twin Crank Lago Petroleum Corporation, La Saline, Venezuela.

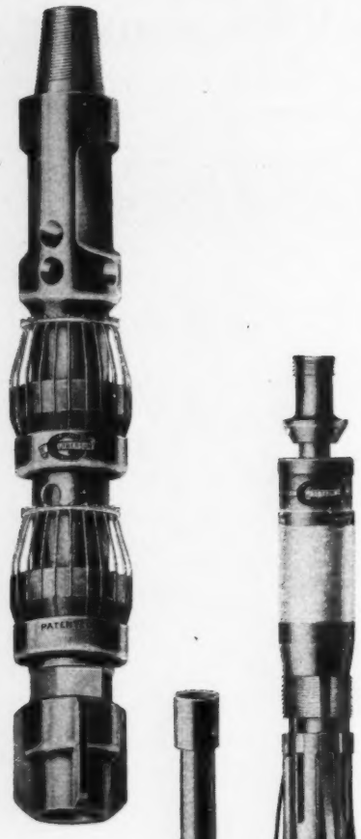


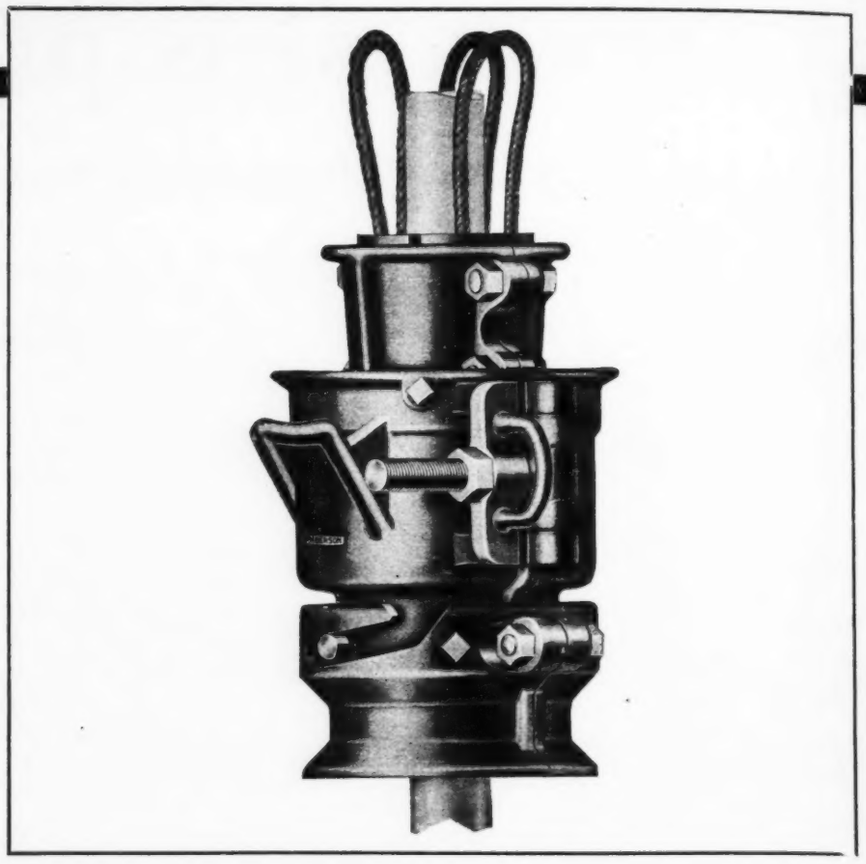
HM-60 Unit—55-hp.—Equipped for multi-well service. Fair & Thompson, Inc., Turnertown, Texas.

THE INTERNATIONAL DERRICK & EQUIPMENT CO.

COLUMBUS, O. BEAUMONT, TEXAS LOS ANGELES, CALIF.

U. S. A.





When Wells Are Put "On the Pump"

To prevent gas and oil from leaking by, when tubing is being run or pulled—and for real *speed* of action—the automatic GUIBERSON Tubing Stripper has no competition. It forms an absolute seal between tubing and casing. Pulling crews want it, for it keeps poison gas, oil and slush off of the men. Made in two halves permanently hinged at back and with strong screw latch at front.

The GUIBERSON Packer is unequalled for forming a tight, dependable pack, at any depth, between tubing and casing, and confining the flow to the tubing. The GUIBERSON Tubing Catcher, inserted as a short section of tubing near bottom of string, automatically stops the tubing from falling and causing a tedious fishing job or even abandonment of the well. The GUIBERSON Swab is superior to all other swabs for any swabbing job.

All GUIBERSON specialties are patented. Phone our Dallas office and we will have one of our field men call on you promptly.

THE GUIBERSON CORPORATION

BOX 1106, DALLAS, TEXAS

LOS ANGELES	TULSA	NEWARK, O.
1304 Security Title Ins. Bldg.	504 Wright Bldg.	First and Locust Streets

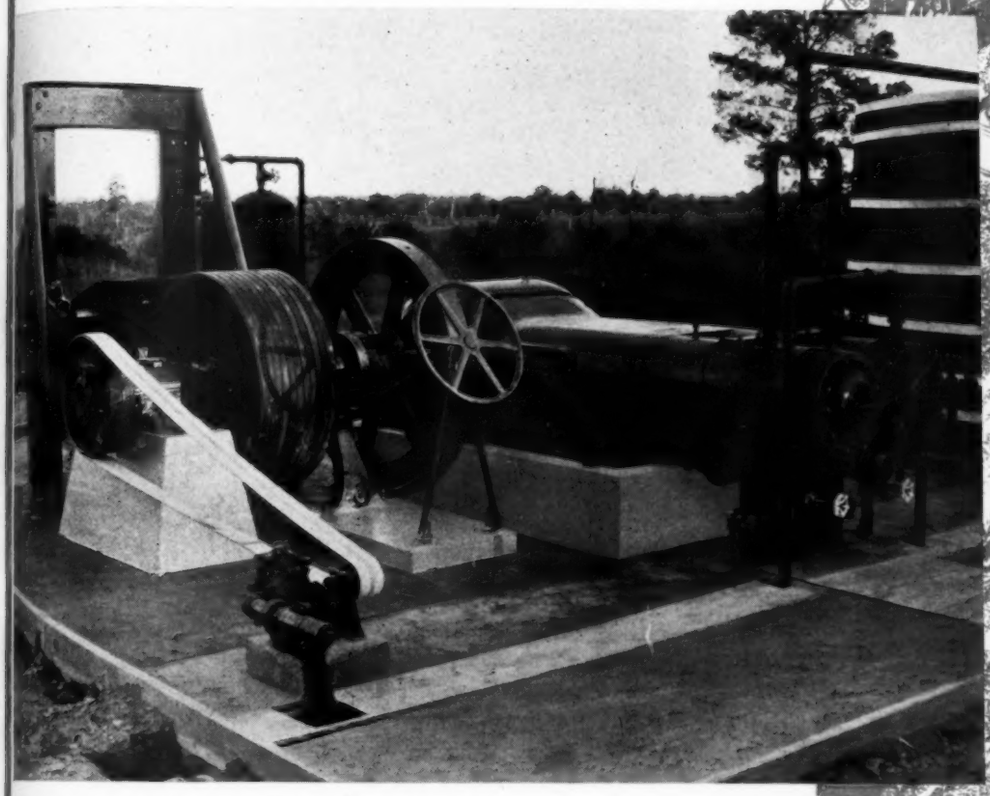
GUIBERSON

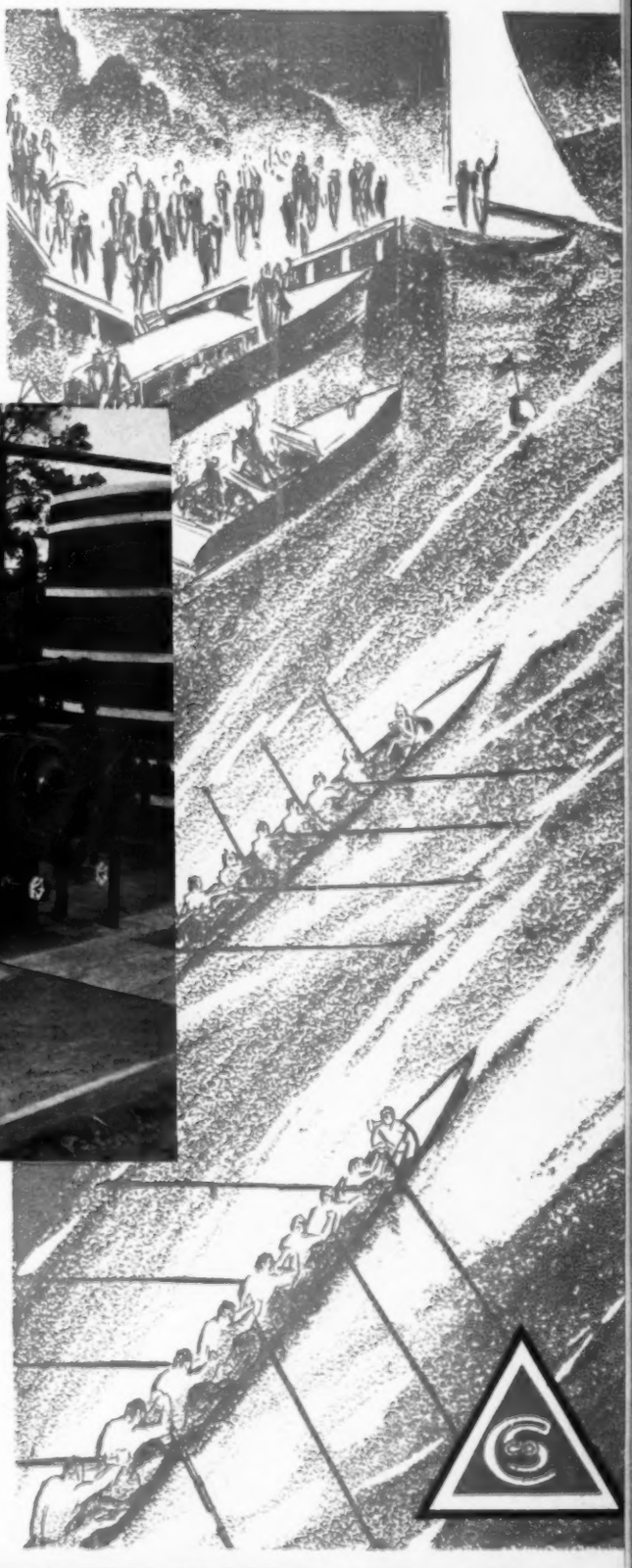
BETTER BE SAFE THAN SORRY — GUIBERSON

SMOOTH FLOW OF POWER

WITH THE

FAIRBANKS-MORSE CONTINENTAL TWIN GAS ENGINE





The smooth even flow of power of these Twin Engines (gas or oil) makes them ideally suited for geared or bandwheel power prime movers.

"Serving the Oil and Gas Industries"

THE CONTINENTAL SUPPLY COMPANY

General Offices: ST. LOUIS

THE CONTINENTAL SUPPLY CO., LTD., 224 Traders Bldg., Calgary, Alberta, Can.
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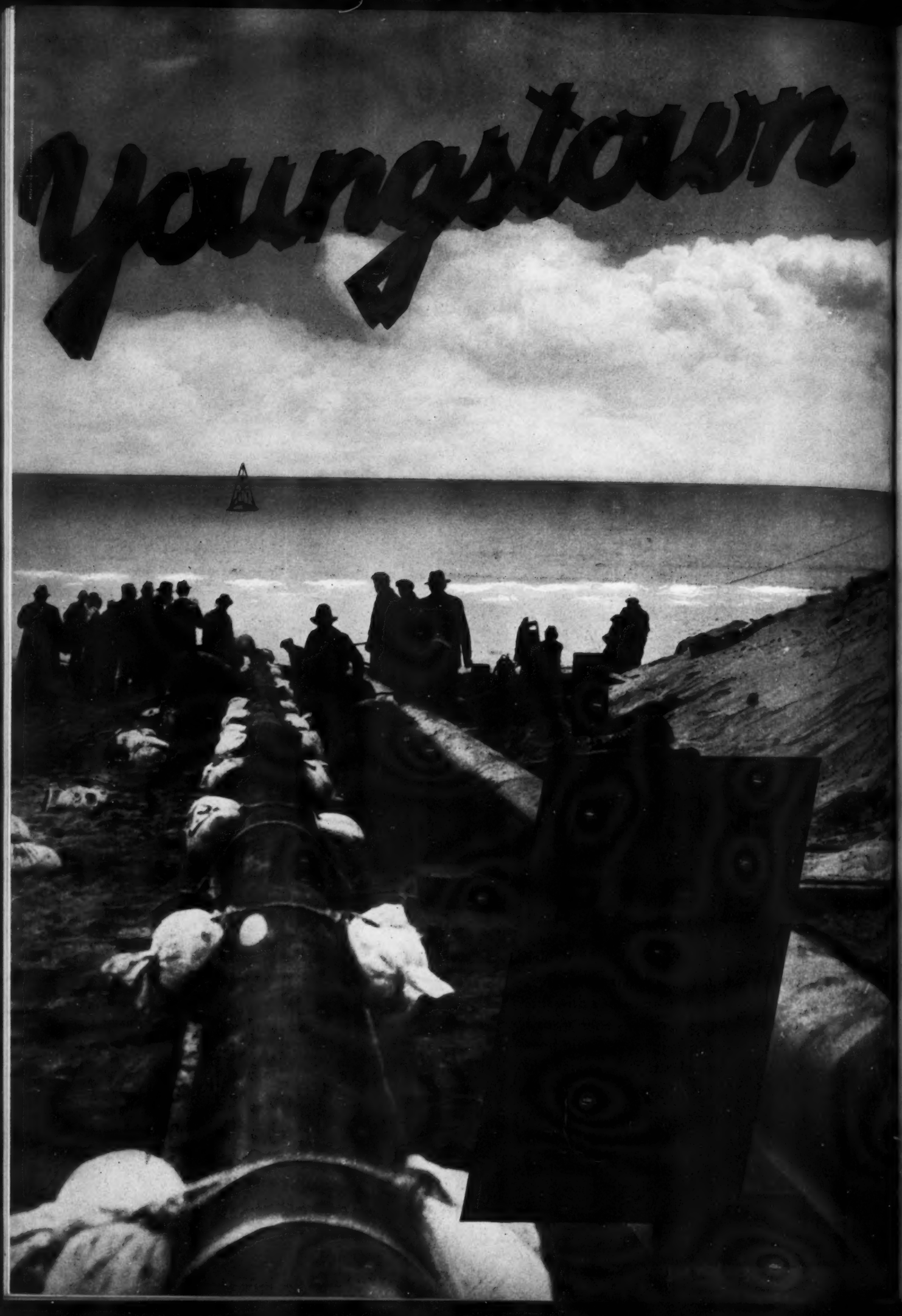
London Offices: Dashwood House, Old Broad Street, London, E. C. 2, England
CONTINENTAL EMSCO S.A.R. Strada Marfurilor, Ploesti, Romania

CONTINENTAL


Youngstown

THEY MADE IT WHAT IT IS TODAY ~ THAT'S WHY THEY'RE SATISFIED

THIS THERMOID BELT WITH THE AMBER FRICTION AND VIOLET EDGES CERTAINLY CHECKS POWER LOSSES
SURE ~ THERE'S NO SLIPPAGE WITH THAT BELT
NO STRETCHING -- OR PLY SEPARATION EITHER
AND DON'T FORGET ITS GREATER FLEXIBILITY AND GREATER DURABILITY
YOU BOYS SEEM TO THINK THERMOID IS A PRETTY GOOD BELT
WE KNOW IT'S GOOD -- WE HELPED TO MAKE IT

A definite knowledge of the user's needs is responsible for the superiorities of the Thermoid Oil Country Belt. Thermoid engineers talked with men in the oil fields . . . carefully noted their comments and incorporated their ideas in producing a belt *built for the job* as only Thermoid can build it. Find out all about the belt *you helped to build* . . . the belt with the amber friction and the violet edge.

Ask us . . . too . . . about: Thermoid Oil Country Belting . . . Rotary Hose . . . Steam Hose . . . Water Hose . . . Fire Hose . . . Suction Hose . . . Air Hose . . . Brake Lining . . . Packings . . . Stuffing Box Rings.

OIL WELL SUPPLY CO.

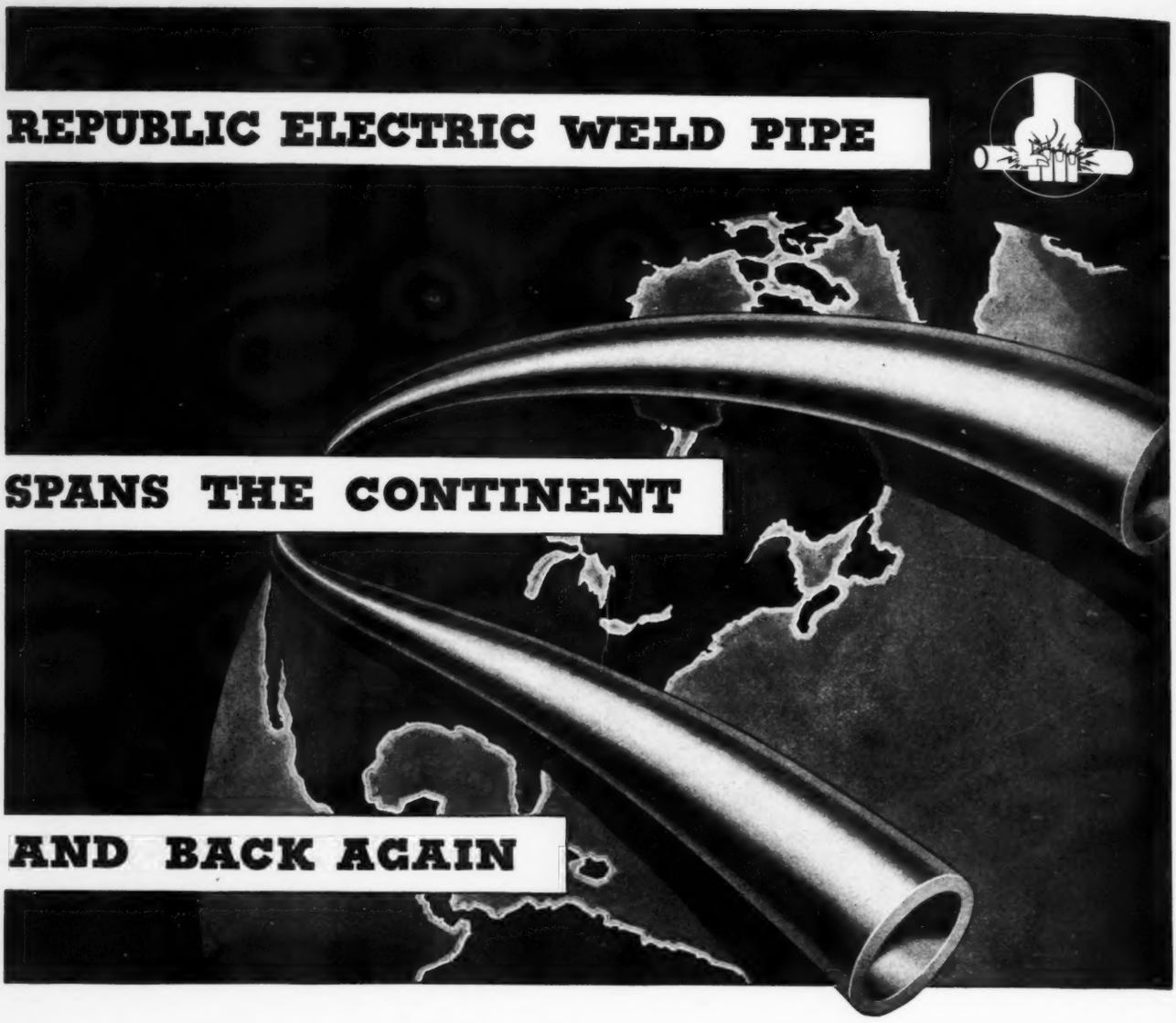
Branch Stores in all Oil Fields

Oil Country Distributors of

Thermoid

BELTING · PACKINGS

BRAKE LINING · HOSE



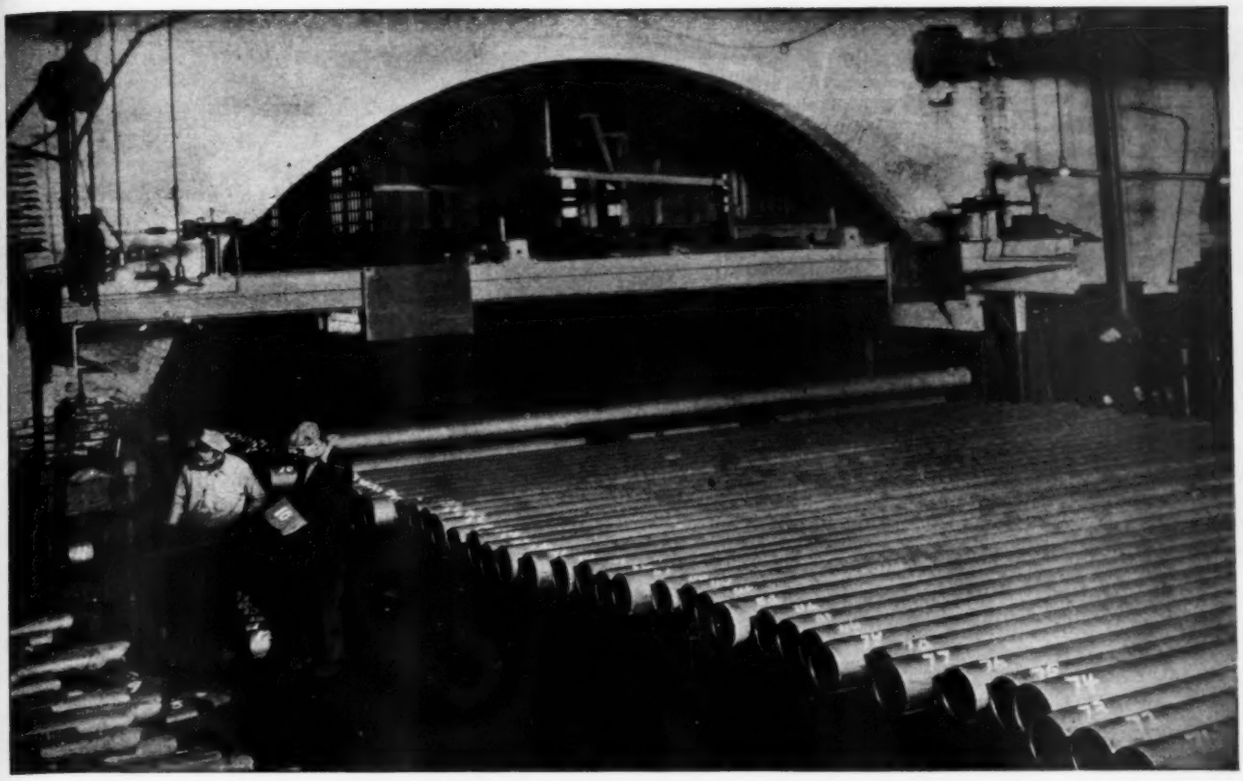
WITH a number of companies buying Republic Electric Weld Pipe for installation all over the country, it's just a little difficult to visualize the tremendous mileage that has been placed in service during the last four years—but if it were all in a single line it would span the continent twice. This means that more than 7000 miles of this better pipe is now carrying oil, gasoline and gas to distribution centers.

Republic Electric Weld Pipe was selected in every case because it is a different kind of pipe with many advantages. Flat steel strip is cold formed to a round and welded by electrical resistance. It is uniform in wall thickness, perfectly round, of uniform diameter, and as strong at the weld as at any other point in the wall. It is free from scale inside and out. These qualities mean tighter joints, pipe without thin spots in the wall, faster construction, easier, quicker welding at joints, and no loose scale to clog when liquids are turned into the line.

If you are interested in knowing more about this pipe that has won such wide recognition, write today for the story contained in our Booklet 210-B. The engineering information in it is well worth having on file.

REPUBLIC STEEL
CORPORATION
GENERAL OFFICES: YOUNGSTOWN, OHIO

REPUBLIC *Electric weld*
LINE PIPE • CASING • TUBING



"CHESTER" Inspection . . .

The above view shows the famous Triple Crop End Crusher Test. The crop ends are flattened down with the weld on the side to 1/3 the outside diameter of the pipe. This tests the weld. The flattened test is then stood on end and mashed nearly flat—after the second flattening the crop is again stood on edge and mashed flat subjecting the steel to a reverse bend. This severe test discloses any defects that might be in the steel.

Just one of the several tests that help maintain the high "Chester" standards.

Chester also makes "Wrought Iron" Pipe—manufactured from genuine old-fashioned hand puddled muck bar made in our own mills from 100% pig iron.

Policy:

The South Chester Tube Company manufactures nothing but tubular goods and its whole organization is devoted entirely to the making of quality pipe.

SOUTH CHESTER TUBE COMPANY, Chester, Pa.

District Sales Managers

W. E. Gibson: 801 Columbia Bank Bldg., Pittsburgh, Pa.
H. A. Morse: 30 Church St., New York, N. Y.
J. P. Cooney: 715-716 A. G. Bartlett Bldg., Los Angeles, Calif.
J. P. Steele: 217 Petroleum Bldg., Ft. Worth, Texas.

District Offices

J. D. Swartz: 1231 S. Evanston St., Tulsa, Oklahoma.
E. L. Moseley: 2218 Mills St., Houston, Texas.
Burt S. Shafer, Southwest Representative: 4313 Fairfax Ave., Dallas, Texas, or 217 Petroleum Bldg., Ft. Worth, Texas

District Warehouses

Houston, Texas; Thenard, Calif.; San Francisco, Calif.

Distributors

United Pipe & Supply Co., Charleston, Danville, West Hamlin, W. Va.; Paintsville, Ashland, Allen, Prestonburg, Ky.

Prichard Supply Co., Mannington, W. Va.; Mather and Waynesburg, Pa.

LeValley, McLeod, Kinkaid Co., Inc., Elmira and Olean, N. Y.

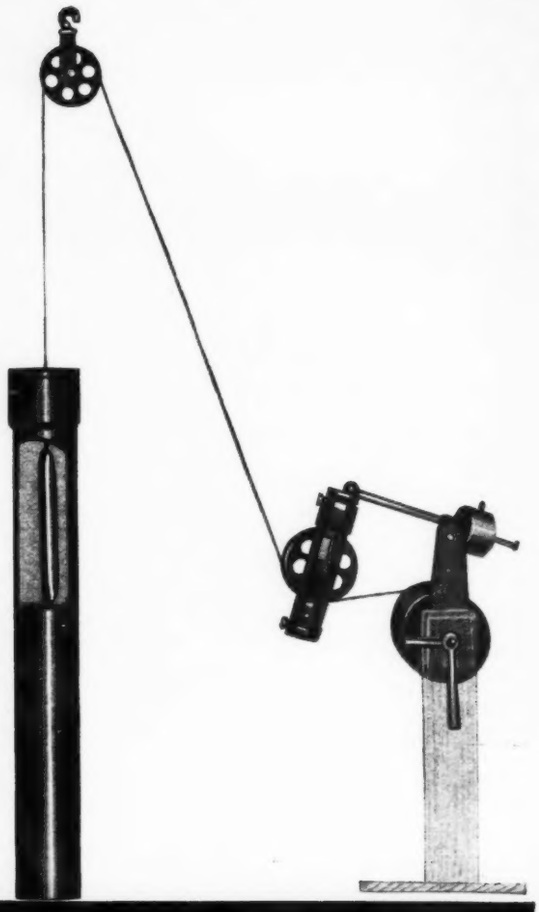
Kane Supply Company, Kane, Lawrenceville, Brookville, Pa.
Bovaird & Co., Bradford, Pa.
Pelican Well Tool & Supply Co., Shreveport, La., Kilgore, Texas.
Great Northern Tool & Supply Co., Billings and Kevin, Mont., Kemmerer and Cody, Wyo.
Star Drilling Machine Co., 550 Clinton St., Portland, Ore., and Akron, Ohio.
Stephen H. McCabe, 508—4th St., San Francisco, Calif.
Barde Steel Company, Seattle, Wash., and Portland, Ore.
Union Supply Corp., Sulphur, La., and Brimstone, La.
Dunigan Tool and Supply Co., Main office Breckenridge, Texas; branch stores. Willow Springs, Pampa, Turnertown, and McCamey, Texas, and Hobbs, N. M.

CHESTER

STEEL SPECIALISTS IN CASING FOR DEEP WELL DRILLING **CASING**

LINE PIPE

THE ACCEPTED AND AUTHENTIC METHOD FOR MEASURING THE DEPTH OF WELLS



■ **Accurate within 2 inches in wells over 5,000 feet deep.**

That in ten words explains the widespread use of the HOWCO WELL MEASURING DEVICE. It explains also why oil men, noting the operation of the device in connection with the Halliburton cementing process, asked us to supply it for general well measuring purposes.

The HOWCO WELL MEASURING DEVICE is engineered in every detail for accurate and economical measuring. . . . It embodies so many advantages that they cannot be set forth in the space here available. We suggest instead that you write for descriptive folder.

Accurate-Economical

Easy to Handle

HALLIBURTON
OIL WELL CEMENTING CO.
Duncan, Oklahoma

HOWCO

WELL MEASURING DEVICE

L. B. HOLLAND, for the past three years superintendent of production for Phillips Petroleum Company in the Oklahoma City district, and who, prior to that time, was located in the company's general offices at Bartlesville, Okla., has been transferred to Breckenridge, Texas. There he will assume the duties of superintendent of production in Arkansas and Texas outside of the Panhandle district. H. L. McQuiston, who has been production superintendent in Kansas, has been promoted to the position vacated by Mr. Holland at Oklahoma City. Mr. McQuiston will also be in charge of production in Southern Oklahoma and the Texas Panhandle.

P. J. DASEY has joined the Cummins Engine Company of Columbus, Ind., as oil field sales engineer. He was formerly connected with the Oil Well Supply Company and the Buda Engine Company.

JACK KOLTHOFF, formerly advertising counselor of Wichita, Kan., has become advertising manager of the Phillips Petroleum Company, Bartlesville, Okla.

WILLIAM T. CONLON has been appointed manager of The Superheater Company's industrial department. In this capacity, Mr. Conlon will have charge of the design, manufacture and sale of Elesco superheaters.

KIRBY SMITH, formerly sales manager for J. H. McEvoy & Company, Houston, Texas, recently resigned his position to become sales manager for the Gulf Coast Machine & Supply Company of Beaumont and Houston.

MORRIS R. PITMAN, petroleum engineer for the Humble Oil & Refining Company, has been transferred from Boling, Texas, to the new Tomball, Texas, field.

W. H. CARSON, for a number of years director of the School of Mechanical Engineering at the University of Oklahoma, has assumed the duties of acting director of the School of Petroleum Engineering. He succeeds H. C. George, who resigned to go to the University of Pittsburgh as head of the department of oil and gas production. Under Carson's direction the Southwestern Gas Measurement Short Course has brought international recognition to the school and, during the past three years, the school has done much cooperative research work with the American Society of Mechanical Engineers.

GLEN M. GILLESPIE, drilling contractor, has recently located at Holdenville, Oklahoma. He was previously residing at Okmulgee, Okla.

D. M. HAMMETT, manager of the Mid-Continent office for the Axelson Manufacturing Company, has successfully undergone an emergency operation for appendicitis and is now recuperating.

J. F. WILSON of the Shell Pipe Line Company has been transferred from Braman, Okla., to the Lucein station in the new Noble County, Okla., field. He is making his home at Orlando.

M. N. DANNENBAUM of the M. N. Dannenbaum Company, Shell Building, Houston, Texas, has returned from the Marshalltown, Iowa, factory of the Fisher Governor Company where he made a detailed study of Fisher equipment to enable him to offer better service for users of Fisher specialties. Mr. Dannenbaum was recently appointed direct factory representative in Southern and Eastern Texas for the Fisher company.

O. G. LAWSON of the firm of Gallagher & Lawson, drilling contractors, has moved to Joinerville, Texas, from Cisco, Texas.

J. R. MCWILLIAMS, for a number of years chief production engineer for the Skelly Oil Company, Tulsa, resigned effective September 1, to become assistant proration umpire for the State of Oklahoma. Mr. McWilliams is an active member of the American Petroleum Institute, and has served on several of its technical committees.

L. C. "LEW" KLEIN, who has been in charge of the oil well division of the American Steel Export Company, Inc., for the past four years recently left the company and has opened his own office to act as export agent for a number of manufacturers of oil field equipment. His office address is Room 601-02, 285 Madison Ave., New York City.

JAMES FOLEY, petroleum engineer with The Texas Company, has been transferred from the Conroe field of the Texas Gulf Coast to Mirando City, Texas.

C. R. TEMPLE of Temple & Kennedy, drilling contractors, has moved from Findlay, Ohio, to Upper Sandusky, Ohio.

JOHN R. KNAPP, production superintendent for the Imperial Oil & Gas Company, who has been located at Owensboro, Ky., is now living at Evansville, Ind.

G. E. RANDELS, district foreman for the Oklahoma Pipe Line Company, has been transferred from Wewoka, Okla., to Wilson, Oklahoma.

R. F. FIKE, superintendent of automotive transportation for the Mid-Continent Petroleum Corporation, Tulsa, Okla., is spending his vacation on the Pacific Coast.

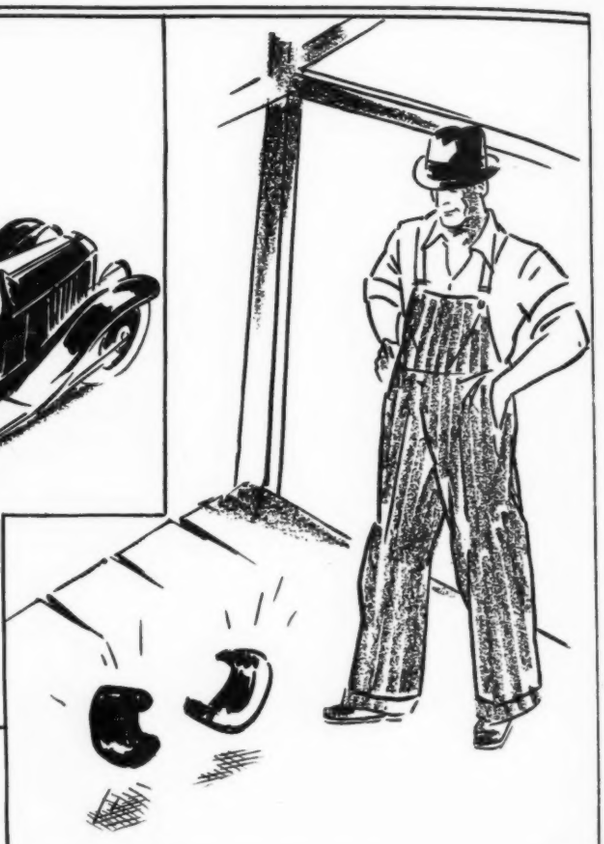
GEORGE SHANER, who has been in the natural gasoline department of the Carter Oil Company at Tulsa, has been transferred to the inspection laboratories of the Standard Oil Company of New Jersey. He will make his home at Jersey City, N. J.

STRANGE... *but* TRUE

HAPPENINGS IN THE PETROLEUM INDUSTRY

Hugh Neumeyer, farm boss for Cron & Gracey, literally burned up an East Texas road. While traveling on a freshly oiled highway recently, oil was splashed on to the exhaust pipe of Neumeyer's car and ignited, the flames following the car for several hundred yards. The automobile itself caught fire but the flames were extinguished before any considerable damage was done.

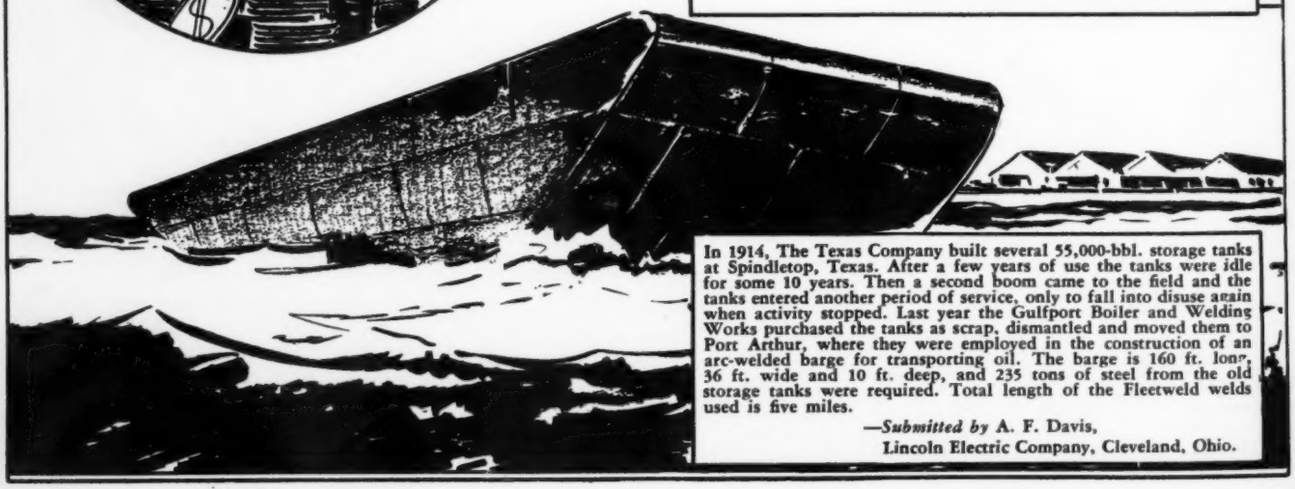
—*Submitted by* Geo. H. Parker,
Parkersburg Rig & Reel Co., Arp, Texas.



Approximately one billion dollars is invested in slightly more than 100,000 miles of oil and gas pipe lines in the United States.

Large chunks of rubber from the packer were recovered while bailing a well in the Taft, Calif., field. The rubber had been in the hole so long that it had become thoroughly impregnated with gas; and immediately the rubber was subjected to the sun's rays, the weather being very hot, the expansion of the gas caused the chunks of rubber to bounce about like Mexican jumping beans, but more animated and over greater distances.

—*Submitted by* Ray M. Humphreys,
Axelson Mfg. Co., of Los Angeles, Calif.



In 1914, The Texas Company built several 55,000-bbl. storage tanks at Spindletop, Texas. After a few years of use the tanks were idle for some 10 years. Then a second boom came to the field and the tanks entered another period of service, only to fall into disuse again when activity stopped. Last year the Gulfport Boiler and Welding Works purchased the tanks as scrap, dismantled and moved them to Port Arthur, where they were employed in the construction of an arc-welded barge for transporting oil. The barge is 160 ft. long, 36 ft. wide and 10 ft. deep, and 235 tons of steel from the old storage tanks were required. Total length of the Fleetweld welds used is five miles.

—*Submitted by* A. F. Davis,
Lincoln Electric Company, Cleveland, Ohio.

TRADE LITERATURE

TRU-LAY YOURS is a monthly publication of the American Cable Company, Park Avenue, New York, N. Y. The August issue describes a new moving picture that presents the complete story of Preformed wire rope.

JENKINS BROS., New York City, has published Catalog No. 23, which not only covers 400 Jenkins Valves, but also gives unusually complete details. The last section of the book contains many pages of engineering data.

A NEW 56-PAGE BOOKLET featuring Universal Cast Iron Pipe and Fittings and Dual-Lok Joint Cast Iron Pipe and Fittings has been published by The Central Foundry Company, 420 Lexington Avenue, New York City. Pouring, chalking and all joint-making equipment are not necessary with this pipe, according to the manufacturers.

FABRICATION OF OXWELDED PIPING is the title of a 156-page book issued by The Linde Air Products Company, New York City. Step-by-step procedures for oxy-acetylene welding steel, cast iron, copper, brass, and lead piping and for making fittings right on the job contribute to the usefulness of this book, in which 75 illustrations and 20 ready-reference tables explains every problem connected with the welding of building and industrial piping.

HARRY F. HALDEMAN, INC., Los Angeles, Calif., has published a new bulletin featuring an interesting graph that shows the effect of odorization of natural gas in relation to unaccounted for losses and leakages. The graph was prepared in coöperation with engineers of one of the largest gas companies in the United States. The graph reveals the interesting fact that prior to odorization leak complaints averaged about 20 per week and as soon as odor was injected the complaints jumped to 400 a week and then settled down to an average of 150 per week.

D. W. HAERING & COMPANY, INC., Chicago, Ill., announce publication of a 16-page booklet on Water Treating. This booklet describes the application of H-O-H treatments to various water problems and explains in detail the cause and effect of many problems common to boiler and hot water equipment.

TRUCK AND TRAILER SIZE AND WEIGHT RESTRICTIONS is the title of a handbook being compiled by F. M. Higgins, Research Department of the Four-Wheel-Drive Auto Company, Clintonville, Wis. The size and weight regulations are condensed in tabular form and can be determined at a glance. All possible truck and trailer combinations are listed in a separate table, giving the total gross loads permissible with each combination.

SPERRY-SUN WELL SURVEYING CO.

1608 WALNUT STREET, PHILADELPHIA, PA.

DALLAS, TYLER AND HOUSTON, TEXAS. TULSA, OKLAHOMA AND LOS ANGELES, CALIFORNIA

SURWEL (Gyroscopic) • **SYFO** (Ink Bottle)

UNDERGROUND WELL SURVEYING SERVICE

ARMSTRONG BROS.

CHAIN TONGS

Standardize on these stronger, more dependable, longer lasting tongs.

JAWS forged from special steel, hardened, tempered and tested. HANDLES are forged from high carbon steel and have both stiffness and "spring." CHAINS are proof-tested to two-thirds catalog strength (3,600 to 40,000 lbs.) Jaws have increased bearing on the handle. Large steel bolt; forged shackle. When buying Pipe Tools look for the Arm-and-Hammer. It guarantees an improved tool—improved design, material and workmanship.

Write for Catalog

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
331 North Francisco Ave., CHICAGO, U. S. A.

The Petroleum Engineer Publishing Company,
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Date .....

Enter my subscription to the Petroleum Engineer from above date for one year, to be sent to me at address below, for which I hereby hand you (check) (cash) in the amount of $1.00 ($1.65 in Canada).

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(To avoid delay, please do not fail to state your title.)

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FIRST AIR-COOLED DINERS—NOW

The **KATY**

Introduces • •

AIR-COOLED LOUNGE CARS

on the

TEXAS SPECIAL

Determined to provide for its patrons every possible comfort and convenience, the Katy Lines made transportation history two years ago by building a fleet of air-cooled dining cars—the first air-cooled cars to operate in the Southwest.

Now the Katy's famous Texas Special is made still finer and more luxurious by air-cooled lounge car service.

J. F. HENNESSEY, Jr., Asst. to the Pres., St. Louis, Mo., Dallas, Tex.

Famed for its Air-Cooled Diners and Unexcelled Table D'Hote Meals

M-K-T Katy Lines

Does YOUR WELL HAVE TO BE PRIMED?

Like the old-fashioned pump of yesterday, many an oil well has to be primed constantly with new pumps, pump parts and sucker rods. Either form of priming is unnecessary and obsolete today.

Axelson manufactures a complete line of modern pumping equipment so designed as to offer a pump for every well. These pumps and sucker rods are engineered to decrease pumping costs and increase production, backed by an organization with over 40 years' experience in the manufacture of oil field equipment.

Axelson Pumps are made in over 50 types and combinations to fit every oil well condition.

Axelson Sucker Rods are made in three kinds . . . all built to standard requisites.

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FRICK-REID SUPPLY CORPORATION
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Rocky Mountain Distributor:
GREAT NORTHERN TOOL AND SUPPLY COMPANY

AXELSON PUMPS and SUCKER RODS

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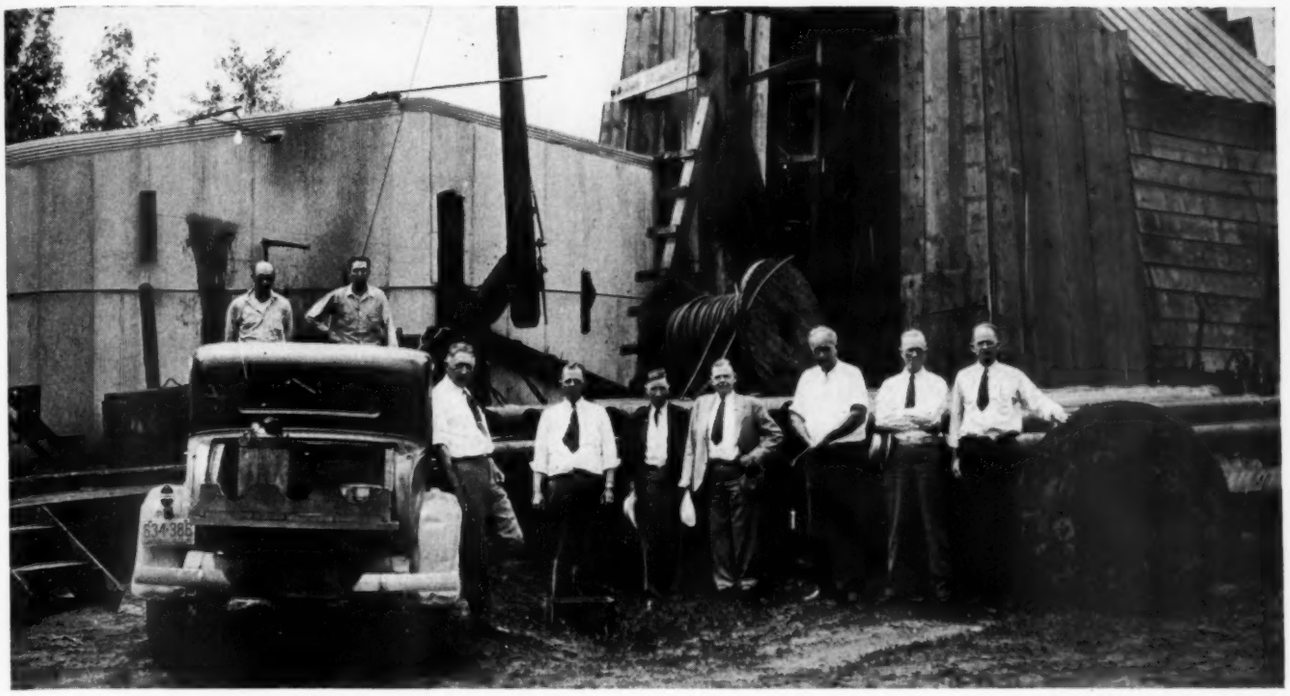

The men above, left to right:

Charles Banks, tooldresser

Dee Dougherty, driller

F. A. Donaldson, Union Wire Rope Corp.

A. H. (Andy) Corbin, Jarecki state representative

Charles Dougherty, contractor

A. E. Butterfield, Attorney for Jarecki Mfg. Co.

R. F. Hair, geologist, holding oil finding instrument

F. E. Markey, contractor

E. F. Snyder, Jarecki Mt. Pleasant store

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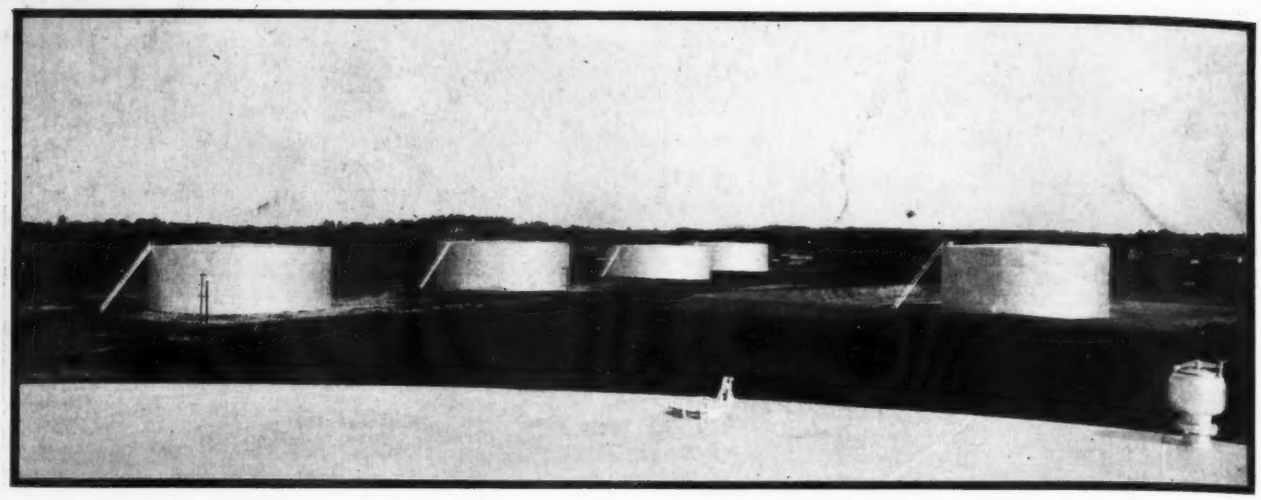
The "ULTIMATE LOW COST WIRE ROPE"



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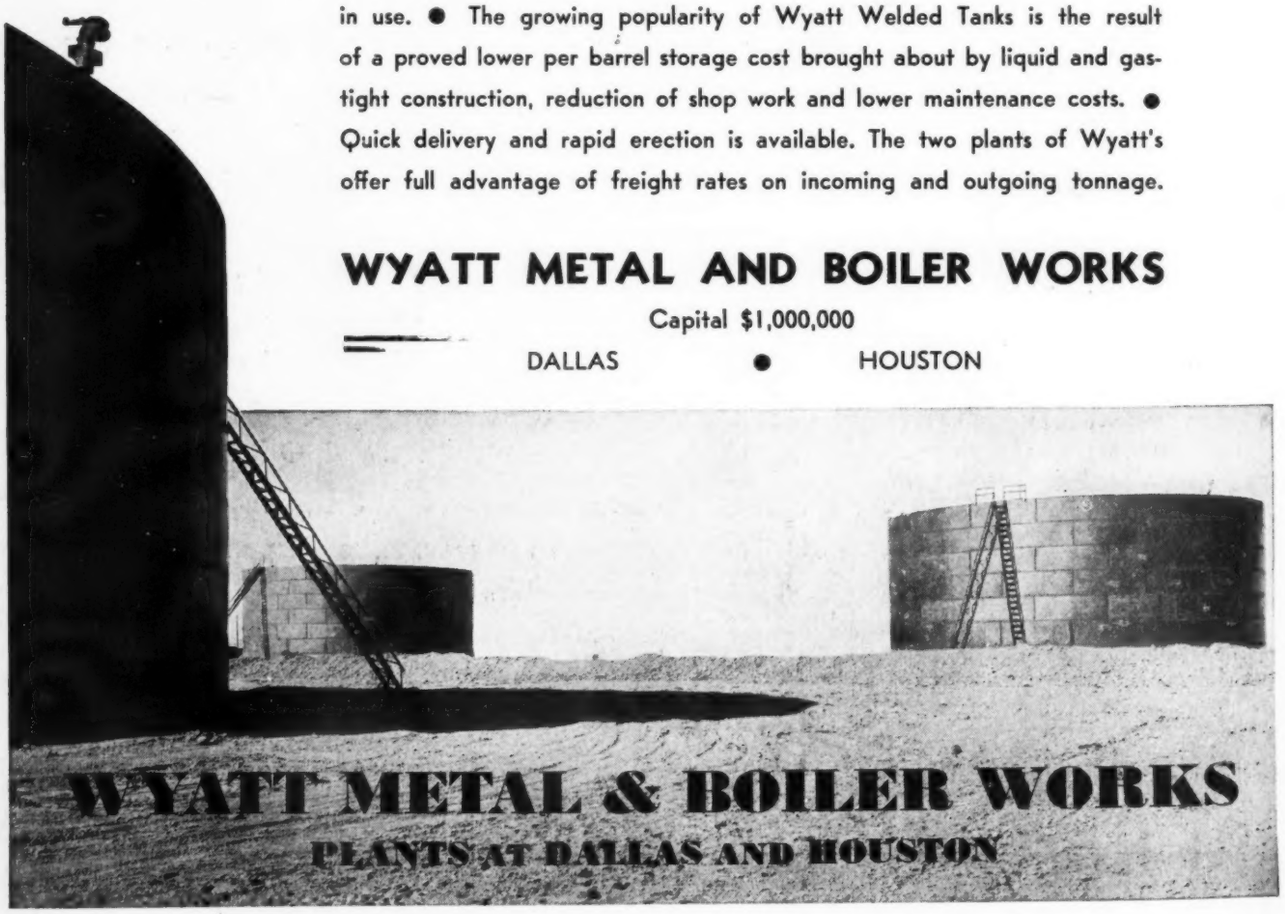
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